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MONITORING THE MIGRATIONS OF WILD SNAKE RIVER SPRING/SUMMER CHINOOK SALMON SMOLTS

Annual Report 1998

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MONITORING THE MIGRATIONS OF WILD SNAKE RIVER SPRING/SUMMER CHINOOK SALMON SMOLTS, 1998

by

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Report of Research

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EXECUTIVE SUMMARY

This reports details the 1998 study results from an ongoing project to monitor the migration behavior of wild spring/summer chinook salmon smolts in the Snake River Basin. The report also discusses trends observed in the cumulative data resulting from this project; data has been collected from Oregon and Idaho streams since 1989.

The project was initiated after 3 years of detection data from PIT-tags (passive-integrated-transponder tags) had shown distinct differences in migration patterns between wild and hatchery fish. Data showing these patterns had originated from tagging and interrogation operations begun in 1988 to evaluate a smolt transportation program conducted by the National Marine Fisheries Service (NMFS) for the U.S. Army Corps of Engineers.

In 1991, the Bonneville Power Administration began a cooperative effort with NMFS to expand tagging and interrogation of wild fish for this project. Project goals were to characterize the outmigration timing of these fish, to determine whether consistent migration patterns would emerge, and to investigate the influence of environmental factors on the timing and distribution of these migrations.

In 1992, the Oregon Department of Fish and Wildlife (ODFW) began an independent program of PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River Basins in northeast Oregon. Since then, ODFW has reported all tagging, detection, and timing information on fish from these streams. However, with ODFW concurrence, NMFS will continue to report arrival timing of these fish at Lower Granite Dam.

We continued to tag fish from Idaho in all years subsequent to 1992. Principal results from our tagging and interrogation efforts during 1997-1998 are enumerated below.

1) In August 1997, we PIT tagged and released 2,685 wild chinook salmon parr in 5 Idaho streams.

2) Average overall observed mortality from collection, handling, tagging, and after a 24-hour holding period was 2.6%.

3) In 1998, we revised our method for expanding detection numbers to account for fish that passed interrogation sites without being detected. However, overall first-time detection rates at the dams in 1998 were higher than those in previous years whether using the revised expansion method, the initial expansion method, or the raw data.

   Detection rates based on the method used from 1993 to 1997 at the dams yielded an overall average of 32.3% in 1998 (range 23.4-58.5% depending on stream of origin). Using the revised expansion method, estimated parr-to-smolt survival to Lower Granite Dam averaged 25.7% (range 18.6-47.6% depending on stream of origin).

4) Fish that were larger at release were detected at a significantly higher rate the following spring and summer than their smaller cohorts ($P < 0.001$).

5) Fish that migrated through the dams in April and May were significantly larger at release than fish that migrated after May ($P = 0.003$).

6) In 1998, peak detections at Lower Granite Dam of all summer-tagged wild fish (from the five streams in Idaho and three streams in Oregon) occurred during variable but increasing flows from late April to early May, with the 50th and 90th percentile passage occurring on 1 and 25 May, respectively. In 1997 and 1998, flows peaked on 18 and 27 May, respectively; however, most wild fish had passed the dam by mid-May, before these peak flows occurred.

Over the years, migration timing patterns have emerged for some stocks; these patterns range from early to late spring at Lower Granite Dam. The passage distribution shifts observed in these stocks over the years appear related to annual climatic conditions.

Annual arrival timing of individual stocks at Lower Granite Dam provides the basis to determine similarities or differences in migration patterns between years or between stocks. For fish from the South Fork of the Salmon River, we now have 9 years data on arrival timing at Lower Granite Dam. Using this data, we estimated 95% CIs for arrival date at the dam for the 10th, 50th, and 90th percentile passages from 17 to 25 April, 5 to 15 May, and 4 to 16 June, respectively. For fish from the Secesh River, we now have 10 years of arrival timing data; we estimated 95% CIs for arrival at the dam for the 10th, 50th, and 90th percentile passage dates from 12 to 19 April, 22 April to 2 May, and 25 May to 16 June, respectively.

We have also observed a 2- to 3-week shift in timing of combined wild stocks passing Lower Granite Dam between relatively warm and relatively cold years. In the warm years of 1990, 1992, 1994, and 1998, the median passage date at the dam was between 29 April and 4 May, and 90% of all wild fish passed by the end of May. In the cold years of 1989, 1991, and 1993, median passage did not occur until mid-May, and the 90th percentile had not passed until mid-June (except during high flows in 1993, when the 90th percentile passed by the end of May).

In 1995, weather conditions in late winter and early spring were moderate compared to those of the previous 6 years, and we observed intermediate passage timing at the dam relative to previous study years, with the median and 90th percentile passage occurring on 9 May and 5 June, respectively. In 1996 and 1997, too few Idaho fish were detected to make meaningful comparisons of timing with other years.

CONTENTS

INTRODUCTION

Background

In 1988, the National Marine Fisheries Service (NMFS) began a cooperative study with the U.S. Army Corps of Engineers (COE) to mark wild Snake River spring and summer chinook salmon parr with Passive Integrated Transponder (PIT) tags for transportation research. This project continued through mid-1991, with migrating smolts monitored as they passed Lower Granite, Little Goose, and McNary Dams during spring and summer 1989-1991 (Matthews et al. 1990, 1992; Achord et al. 1992, 1996b).

Information from these 3 years of study demonstrated that the migration timing of wild stocks through Lower Granite Dam differs among stream of origin and also differs from the migration timing of hatchery-reared fish. Migrations of wild spring chinook salmon were consistently later and more protracted than those of their hatchery-reared counterparts and exhibited more variable timing patterns over the 3 years. In contrast, the migrations of wild summer chinook salmon during these same years were earlier, though also more protracted, than those of their hatchery counterparts.

The present study began in mid-1991, when NMFS and the Bonneville Power Administration (BPA) began a cooperative ongoing project to monitor the migrations of wild chinook salmon smolts (Achord et al. 1994). During 1992, the first year of monitoring under the project, warm weather and high water-temperatures in late winter and spring appeared to elicit an earlier migration timing for all wild smolts than in the previous 3 years. Also, most wild summer chinook salmon smolts migrated earlier than wild spring chinook salmon smolts. However, consistent with observations from the previous 3 years, all wild stocks exhibited protracted and variable migration timing at Lower Granite Dam.

In 1993, cold weather and low water-temperatures from late winter to early summer appeared to elicit late migration timing; however, high flows during the third week of May moved a large portion of wild spring/summer chinook salmon smolts through the dams (Achord et al. 1995a). As observed in previous years, wild stocks exhibited variable migration timing at Lower Granite Dam; however, the time period for the middle 80% passage of wild fish stocks at the dam was more compressed in 1993 than in earlier years.

In 1994, migration timing of wild spring/summer chinook salmon smolts at Lower Granite Dam was similar to timing observed in 1990 and 1992, with peak passage in all 3 years occurring in April; however, peak detections of fish from individual streams in 1994 occurred from late April to late May (Achord et al. 1995b). As observed in 1990 and 1992, temperatures in 1994 were high in late winter and spring.

Before 1995, we observed a 2- to 3-week shift in the overall timing of wild fish at Lower Granite Dam between relatively cold and relatively warm years. In the cold years of 1989, 1991, and 1993, median passage at the dam for all wild fish occurred by mid-May, and the 90th percentile passed by mid-June (except in 1993, when the 90th percentile passed by the end of May under high flows). In the warm years of 1990, 1992, and 1994, 50% of all wild fish passed this dam from 29 April to 4 May, and 90% passed by the end of May.

In 1995, weather conditions in late winter and early spring were moderate compared to the previous 6 years, and we observed intermediate passage timing at the dam, with 50 and 90% passage occurring on 9 May and 5 June, respectively (Achord et al. 1996a). Sustained high flows from mid-May to early June in that year moved the later half of the wild fish migration through the dam at a more uniform rate than in previous years, and over 90% had passed by the time peak flows occurred at the dam on 6 June.

In 1996, as observed in all previous migration years, peak detections of all wild fish at Lower Granite Dam were highly variable and generally independent of river flows before about 9 May, but coincided with periods of peak flow at the dam from 9 May to the end of May (Achord et al. 1997). In 1996, the median and 90th percentile passage dates of wild PIT-tagged fish from combined Idaho and Oregon streams at Lower Granite Dam were 3 and 22 May, respectively. Few wild fish from Idaho streams were marked as parr in 1995 and 1996; as a result, detections at the dam were composed of fish from Oregon streams in proportions of 91% in 1996 and 73.5% in 1997. Therefore, we caution against comparing migration timing in 1996 and 1997 to timing in other years, since in all other years, less than 50% of wild fish detections were fish from Oregon streams.

In 1997, peak detections of all wild spring/summer chinook salmon smolts from Idaho and Oregon at Lower Granite Dam occurred during variable but increasing flows in April (Achord et al. 1998). High river-flows from mid-April to mid-May moved most of these fish through the dam, with 50 and 90% passage occurring on 24 April and 21 May, respectively.

Project Goals

Prior to 1992, decisions on dam operations and use of stored water relied on recoveries of branded hatchery fish, index counts at traps and dams, and flow patterns at the dams. In 1992, a more complete approach was undertaken, with the addition of PIT-tag detections of several wild spring and summer chinook salmon stocks at Lower Granite Dam. We initiated development of a database on wild fish, which addresses several goals of the Columbia River Basin Fish and Wildlife Program of the Pacific Northwest Electric Power Planning Council and Conservation Act (1980). Section 304(d) of the program states, "The monitoring program will provide information on the migrational characteristics of the various stocks of salmon and steelhead within the Columbia Basin."

Further, Section 201(b) urges conservation of genetic diversity, which will be possible only if wild stocks are preserved. The advent of PIT-tag technology has provided the opportunity to precisely track the smolt migrations of many wild stocks as they pass through the hydroelectric complex and other monitoring sites on their way to the ocean.

The goals of this study are 1) to characterize the migration timing of different stocks of wild Snake River spring/summer chinook salmon smolts at dams on the Snake and Columbia Rivers, 2) to determine whether consistent migration patterns are apparent, and 3) to determine what environmental factors influence these patterns.

This report provides information on PIT tagging of wild chinook salmon parr in 1997 and the subsequent monitoring of these fish. Fish were monitored as they migrated through juvenile migrant traps in 1997 and 1998 as well as through interrogation systems at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams during 1998.

METHODS

Fish Collection and Tagging

In 1992, Oregon Department of Fish and Wildlife (ODFW) began PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River drainages in northeast Oregon. All tagging, detection, and timing information for fish from these streams in 1997-1998 will be reported by ODFW. However, with ODFW's concurrence, NMFS will continue to report the timing at Lower Granite Dam of summer-tagged fish from Oregon streams.

Due to low numbers of returning adult spring/summer chinook salmon to Idaho in 1996 and subsequent low numbers of parr in the streams in 1997, the Idaho Department of Fish and Game (IDFG) allowed collection of parr in only three streams of the South Fork of the Salmon River drainage and in an additional two streams in the Middle Fork of the Salmon River drainage (Fig. 1). Collection and PIT-tagging procedures described by Matthews et al. (1990) and Achord et al. (1994; 1995a,b) were used for our field work in 1997.

Juvenile Migrant Traps

During fall 1997 and spring 1998, juvenile migrant fish traps were operated at Knox Bridge on the South Fork of the Salmon River, at the South Fork of the Salmon River below its confluence with the Secesh River, at Lake Creek, near Chinook Campground on the Secesh River, at Marsh Creek, and near the Sawtooth Hatchery on the upper Salmon River (Fig. 1). Also during spring 1998, juvenile migrant fish traps were operated on the lower Salmon River near Whitebird, Idaho, and on the Snake River at Lewiston, Idaho (Fig. 1). Traps were operated by the Nez Perce Tribe (NPT) and IDFG.

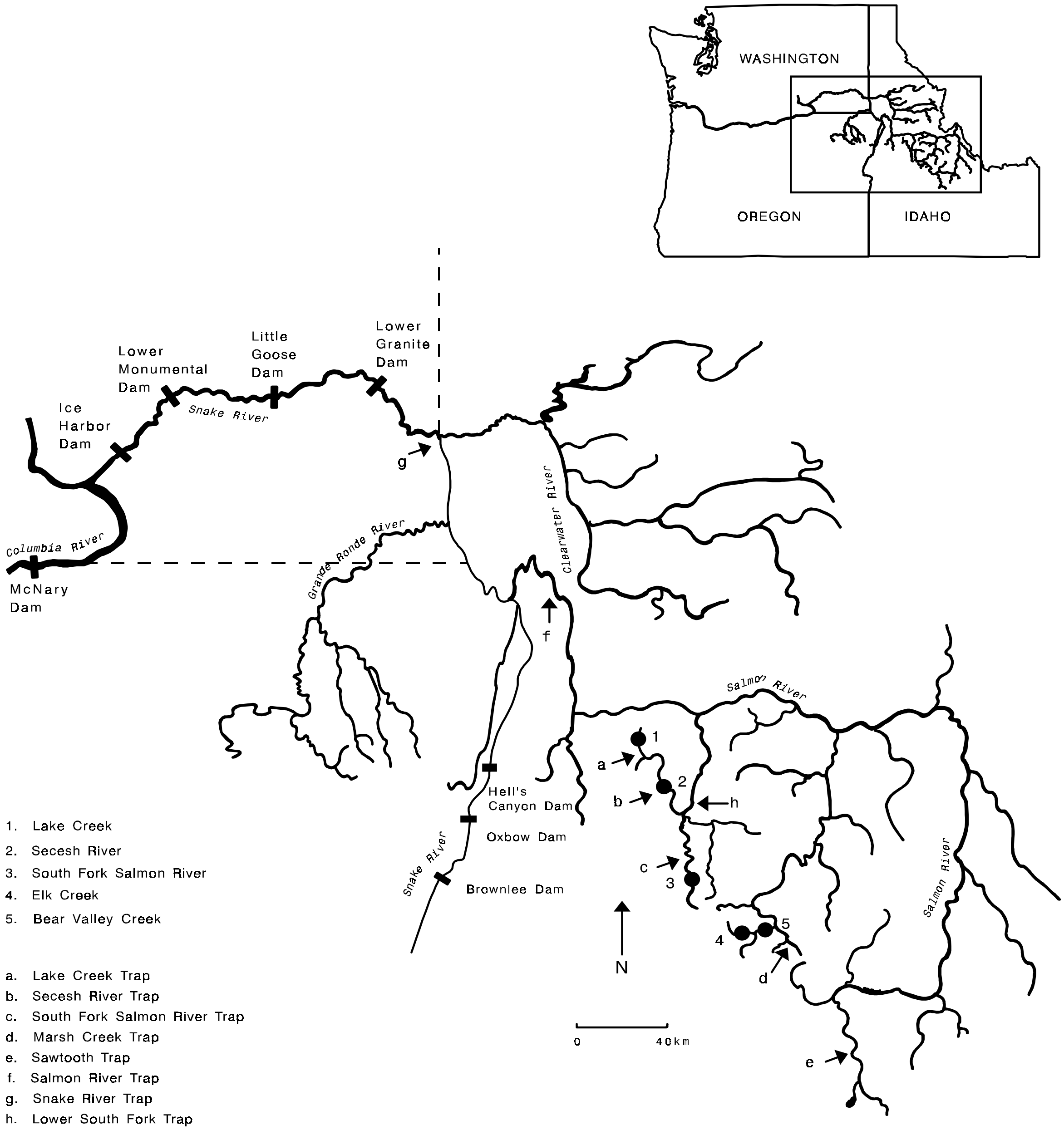


Figure 1. Area where wild spring/summer chinook salmon parr were PIT tagged during 1997. Map includes juvenile salmonid migrant fish traps and four PIT-tag interrogation dams. Two dams below McNary Dam, John Day and Bonneville Dams, are interrogation dams.

Interrogation at Dams

During spring, summer, and fall 1998, surviving chinook salmon PIT tagged for this study migrated volitionally downstream through hydroelectric dams on the Snake and Columbia Rivers. Of the eight dams the smolts passed, the following six were equipped with smolt collection and/or PIT-tag interrogation systems: Lower Granite, Little Goose, and Lower Monumental Dams on the Snake River (Fig. 1), and McNary, John Day, and Bonneville Dams on the Columbia River.

At these six dams, all smolts guided from turbine intakes into juvenile bypass systems were electronically monitored for PIT tags. The PIT-tag interrogation systems were the same as those described by Prentice et al. (1990). Dates and times to the nearest second were automatically recorded on a computer as PIT-tagged fish passed each detector. All detection data were transferred once daily to the mainframe computer operated by the Pacific States Marine Fisheries Commission in Portland, Oregon.

Migration Timing

During the years of spill from 1993 to 1997, migration timing at each interrogation dam was analyzed based on first-time detection numbers expanded relative to the proportion of daily spill (Achord et al. 1995a,b; 1996b, 1997, 1998). This produced a spill-adjusted or indexed number of PIT-tagged fish passing each dam daily for individual or combined populations. In 1998, we used the spill-adjusted numbers only for comparisons with data from previous years.

In 1998, within-season migration timing at Lower Granite Dam was analyzed based on daily detection numbers expanded relative to estimated daily detection probabilities. Detection probabilities were calculated using the methods of Sandford and Smith (In prep.) to provide an estimate of the number of PIT-tagged wild spring/summer chinook salmon smolts that passed the dam each day. At interrogation dams below Lower Granite Dam, migration timing was based simply on first-time detections (no adjustments were calculated).

Migration timing at all dams was calculated by totaling the number of detections in 3-day intervals and dividing by total detections during the season (expanded numbers were used only for detections at Lower Granite Dam). This method was applied to detection data for fish from individual and combined streams. Migration timing at Lower Granite Dam was calculated for smolts from individual streams in Idaho and Oregon, while migration timing at all interrogation dams was calculated for smolts from all Idaho streams combined at all interrogation dams except John Day and Bonneville Dams.

There was no straightforward way to compare within-season passage timing dates among stocks from different streams to discern statistically significant differences in arrival timing at Lower Granite Dam. Therefore, we used an approach analogous to analysis of variance with multiple comparisons between the 10th, 50th (median), and 90th percentile passage timings at the dam. Bootstrap methods were used to calculate estimates of the standard error for each statistic (Efron and Tibshirani 1993). A "representative" estimate of variance for each statistic was then calculated as the median of the standard errors for all eight streams. The Student-Newmann-Keuls (SNK), multiple comparison method ($\alpha = 0.05$) was used to make comparisons between streams for each statistic (Petersen 1985).

Environmental Information

Data from five environmental monitoring systems were used. Environmental information was collected from monitoring systems at the following locations: 1) in Marsh Creek, 2) in Valley Creek, 3) near Sawtooth Hatchery in the upper Salmon River, 4) in the South Fork of the Salmon River by Knox Bridge, and 5) near the Chinook Campground in the Secesh River. All monitoring systems except the system at Valley Creek were adjacent to juvenile migrant fish traps.

RESULTS

Fish Collection and Tagging

From 12 to 22 August 1997, we collected 3,698 wild chinook salmon parr in Idaho over a distance of about 18 stream kilometers (Table 1; Appendix Table 1). Of these fish, 2,685 were PIT tagged and released back into the streams; the remainder were rejected for tagging because of size, injury, or precocious maturation and released back to the streams. Numbers released per stream ranged from 246 in Elk Creek to 1,006 in the South Fork of the Salmon River (Appendix Table 2). Fork lengths of tagged and released wild fish ranged from 52 to 131 mm (mean 66 mm) and weights ranged from 1.2 to 11.3 g (mean 3.7 g).

Other than chinook salmon parr, sculpin were the most abundant species observed during electrofishing operations (Table 2). However, these numbers do not represent total abundances of fish in the areas of collection.

Mortality associated with collection and tagging procedures was low, and 24-hour tag loss was zero (Table 3; Appendix Table 3). Average collection mortality was 2.3%, and average tagging and 24-hour delayed mortality was 0.3%. The average overall observed mortality was 2.6%.

Detections at Traps

A total of 77 previously PIT-tagged wild spring/summer chinook salmon from the South Fork of the Salmon River were detected at the Knox Bridge juvenile migrant fish trap in fall 1997 and spring 1998. Of these, 72 were recaptured, weighed, measured, and re-released at the trap in the fall. They had grown an average of 3.4 mm in length (range 0-11 mm) over an average of 30.7 days (range 0-54 days). Five wild fish from the summer tagging were detected at the trap in spring and summer 1998. They had grown an average of 21.2 mm (range 9-58 mm) over an average of 254.6 days (range 202-376 days).

Ten summer-tagged parr from the Secesh River, Lake Creek, and the South Fork of the Salmon River were detected at the trap on the lower South Fork of the Salmon River. Nine were detected in the fall and had grown an average of 8 mm (range 4-16 mm) over an average of 68.1 days (range 59-79 days). One was detected in the spring and had grown 22 mm over 208 days. One summer-tagged parr from the Secesh River was detected in the spring of 1998 at the Secesh River trap and had grown 16 mm over 251 days. Detection information on our summer-tagged parr (under coordinator ID "SA") was not collected during summer and fall 1997 at the Lake Creek and Secesh River traps.

Table 1. Summary of collection, PIT-tagging, and release of wild chinook salmon and steelhead parr with average fork lengths and weights and approximate distances covered in streams of Idaho during August 1997.

Tagging location	Number collected	Number tagged and released	Average length of tagged fish (mm)	Average weight of tagged fish (g)	Kilometers covered in streams
Chinook Salmon					
S. Fork Salmon River	1,655	1,006	64.0	3.3	3
Secesh River	873	588	63.0	3.1	4
Lake Creek	476	418	63.0	3.5	2
Bear Valley Creek	441	427	75.0	5.9	5
Elk Creek	253	246	77.0	6.3	4
Totals	3,698	2,685	66.0	3.7	18
Steelhead[a]					
S. Fork Salmon River	534	94	--	--	--
Secesh River	236	93	--	--	--
Lake Creek	52	23	--	--	--
Bear Valley Creek	497	96	--	--	--
Elk Creek	107	94	--	--	--
Totals	1426	400	--	--	--

[a] Steelhead were PIT-tagged at the request of Idaho Department of Fish and Game.

Table 2. Summary of species other than chinook salmon and steelhead parr observed during electrofishing operations in five streams in Idaho in August 1997 (Note: Numbers in parentheses represent brook trout sampled for whirling disease analysis or sculpin, dace, and sucker vouchered for identification).

Stream	Brook trout	Whitefish	Cutthroat trout	Bull trout	Sculpin	Dace	Sucker
South Fork Salmon River	56 (56)	4	0	0	367 (6)	9 (6)	40 (1)
SeceshRiver	35 (29)	6	0	3	237 (6)	1	0
LakeCreek	80 (31)	5	0	1	187	7 (6)	0
BearValleyCreek	560 (60)	32	0	1	994 (9)	29 (8)	0
ElkCreek	252	21	0	1	624	0	0
Totals	983 (176)	68	0	6	2,409 (21)	46 (20)	40 (1)

Table 3. Mortality and tag loss for wild chinook salmon parr collected and PIT tagged in Idaho, August 1997.

	Mortality (%)				24-hour tag loss (%)
Tagging location	Collection	Tagging	24-hour	Overall	
South Fork Salmon River	1.7	0.2	0.0	1.9	0.0
Secesh River	4.0	0.5	0.0	4.5	0.0
Lake Creek	0.6	0.6	0.0	1.3	0.0
Bear Valley Creek	2.9	0.0	0.0	2.9	0.0
Elk Creek	2.8	0.0	0.0	2.8	0.0
Averages	2.3	0.3	0.0	2.6	0.0

Five summer PIT-tagged fish from Lake Creek, Secesh River, and Elk Creek were detected at the Salmon River juvenile migrant fish trap during spring 1998. They had grown an average of 22.4 mm (range 7-31 mm) over an average of 229.2 days (range 222-237 days). Two summer PIT-tagged fish from the South Fork of the Salmon River were detected at the Snake River trap in spring 1998. They had grown an average of 35.5 mm (range 26-45 mm) over an average of 253 days (range 247-259 days).

From the 5 Idaho streams, 12 other fish that were tagged as parr in summer 1997 were recaptured or the tags recovered at various locations in 1997 and 1998. These locations included Crescent Island, Rice Island, Three Mile Island, Lower Monumental Dam, Little Goose Dam, and Elk Creek.

Detections at Dams

Based on expanded detections at Lower Granite Dam from 31 March to 7 August 1998 (691 fish), survival from parr to smolt averaged 25.7% (range 18.6-47.6%; Table 4; Appendix Tables 4-8). An additional 320 first-time detections were recorded at the other 5 dams (Table 4; Appendix Tables 4-8) and were used for evaluations of migration timing. By comparing all first-time detections at interrogation dams (641) to the expanded number of detections at Lower Granite Dam (691), we estimated that 7.2% of the wild fish from Idaho passed through the hydropower system undetected. The estimated percentage of undetected wild fish from Oregon streams was higher at 18.3%.

For parr tagged in Idaho, average fork length at release was 66 mm. However, of fish from this group that were detected the following spring at the dams, average fork length at release was 69 mm. These length differences were significant (chi-square, $P < 0.001$). The release-length distribution of detected fish was also significantly different from that of released fish in all length categories except 65-69 mm ($P < 0.005$; Fig. 2).

We also found a significant difference in fork lengths at time of release for fish that migrated through the dams in May compared to fish that migrated after May ($P = 0.004$), but no significant differences in fork length at time of release were observed between fish that migrated through the dams in April and those that passed after May ($P = 0.138$). Fish migrating through the dams in April and May were on average 3 mm larger when released than fish migrating after May, and this difference was significant ($P = 0.003$). These data suggest that fish size may influence migration timing or overwintering location with respect to detection at the first dam.

Table 4. Summary of first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at six dams from April to September 1998. Expanded detections at Lower Granite Dam provide estimates of parr-to-smolt survival.

	Detections												
	Lower Granite												
		Expanded		Little Goose		Lower Monumental		McNary		John Day		Bonneville	
Stream	Detected	N	%	N	%	N	%	N	%	N	%	N	%
South Fork Salmon River	83	187	18.6	48	4.8	22	2.2	5	0.5	6	0.6	4	0.4
Secesh River	73	164	27.9	52	8.8	14	2.4	6	1.0	5	0.9	2	0.3
Lake Creek	48	98	23.4	27	6.5	7	1.7	3	0.7	1	0.2	0	0.0
Bear Valley Creek	60	125	29.3	49	11.5	11	2.6	3	0.7	5	1.2	2	0.5
Elk Creek	57	117	47.6	29	11.8	13	5.3	4	1.6	1	0.4	1	0.4
Totals or averages	321	691	25.7	205	7.6	67	2.5	21	0.8	18	0.7	9	0.3

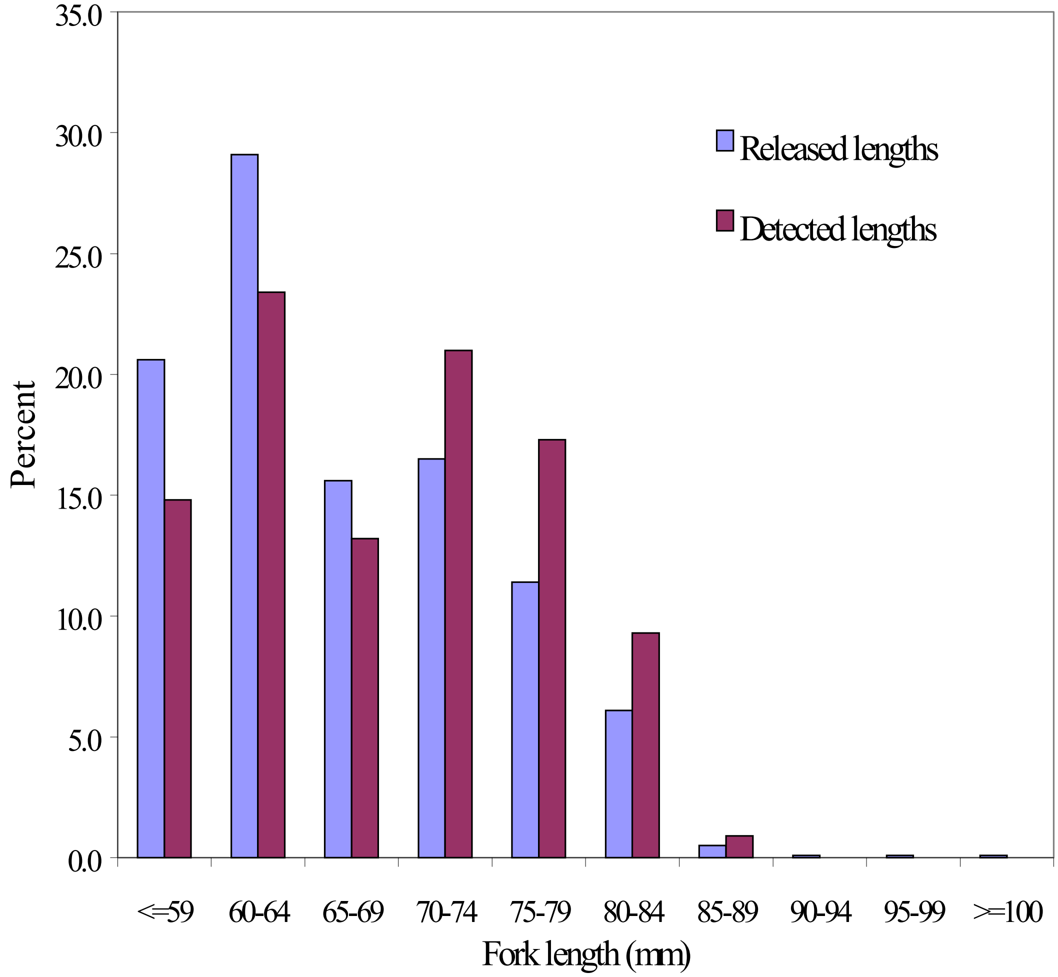


Figure 2. Percent by fork length increments, of PIT-tagged wild spring/summer chinook salmon parr released in Idaho streams in 1997 and percent of fish detected for these length increments at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams in spring and summer 1998.

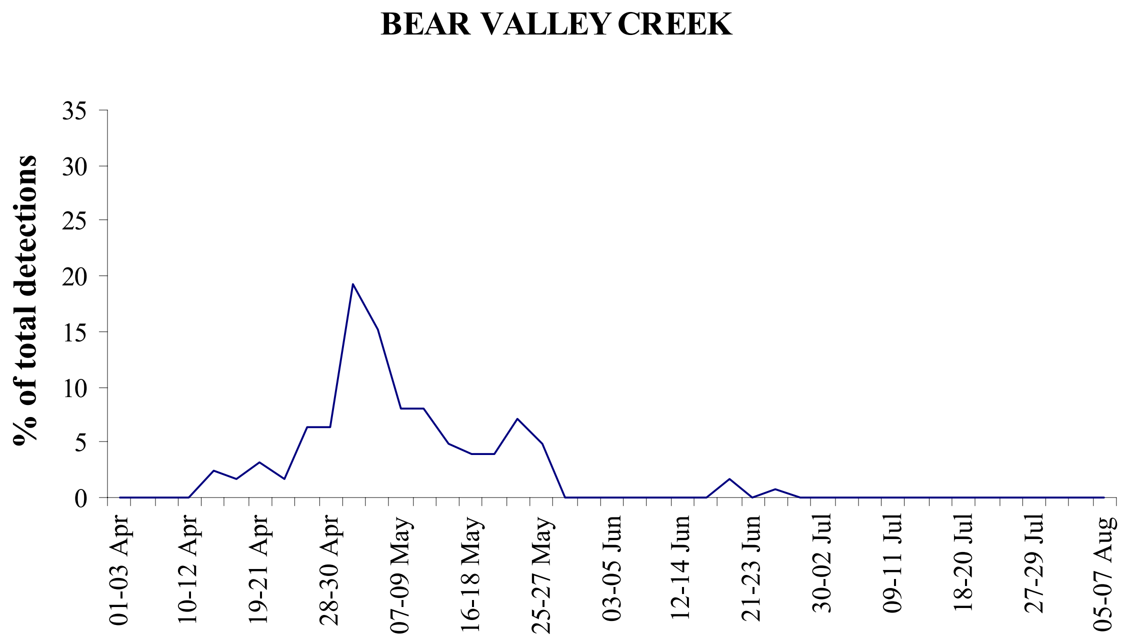
Migration Timing

Detections at Lower Granite Dam of fish from Bear Valley Creek, Catherine Creek, and the South Fork of the Salmon River generally displayed later timing than fish from Elk Creek, Lake Creek, Secesh River, Imnaha River, and Minam River (Fig. 3 and Table 5). Over 50% of fish from the five early streams (except Elk Creek) passed the dam in April, and most peak passage dates for fish from these streams occurred in April (Appendix Tables 5 and 6; Fig. 3). Over half of the fish from the three late streams passed the dam in May, and most peak passage dates for fish from these streams occurred in May (Appendix Tables 4 and 7; Fig. 3).

For the 10th percentile passage distributions at Lower Granite Dam, fish from Lake Creek, Elk Creek, Secesh River, and Minam River had significantly earlier timing than fish from Bear Valley Creek, South Fork of the Salmon River, and Catherine Creek ($P < 0.05$). Fish from Secesh River, Lake Creek, Imnaha River, and Minam River had significantly earlier median passage distribution timing than fish from Bear Valley Creek, South Fork Salmon River, and Catherine Creek ($P < 0.05$).

For the 90th percentile passage distributions, fish from Minam River, Imnaha River, and Elk Creek had significantly earlier timing than fish from Lake Creek, Secesh River, Catherine Creek, and South Fork of the Salmon River ($P < 0.05$). The middle 80th percentile passage distributions were of significantly shorter duration (4.0-5.4 weeks) for fish from Bear Valley Creek, Catherine Creek, Imnaha River, Minam River, and Elk Creek than for fish from Secesh River, South Fork of the Salmon River, and Lake Creek (7.1-7.4 weeks; $P < 0.05$).

Timing of smolts from individual streams in Idaho is not presented here for Little Goose, Lower Monumental, McNary, John Day, or Bonneville Dams; see Appendix Tables 4-8 for this information.



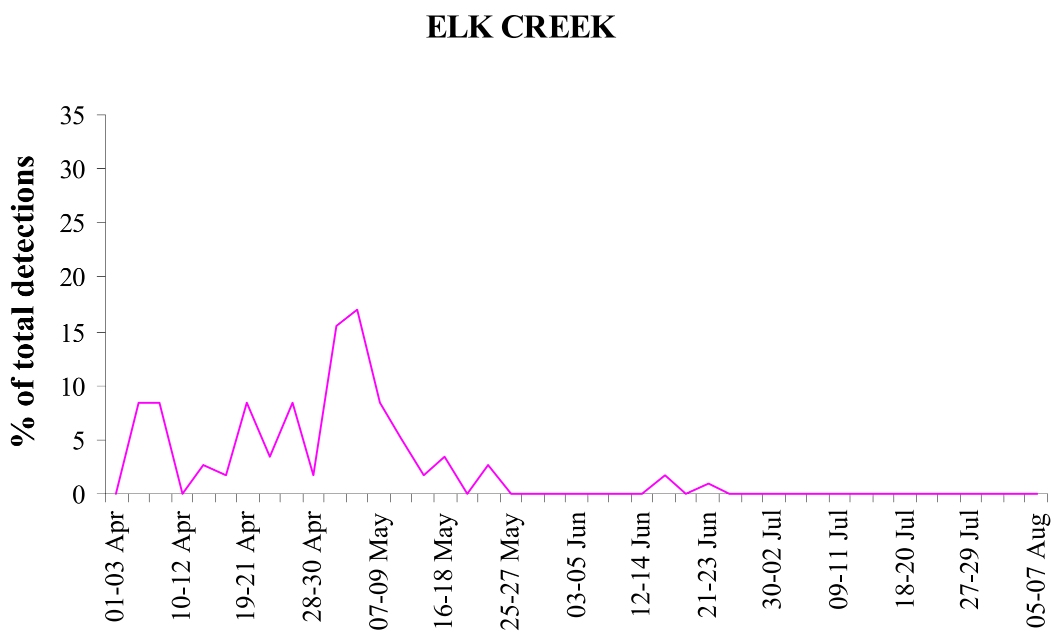
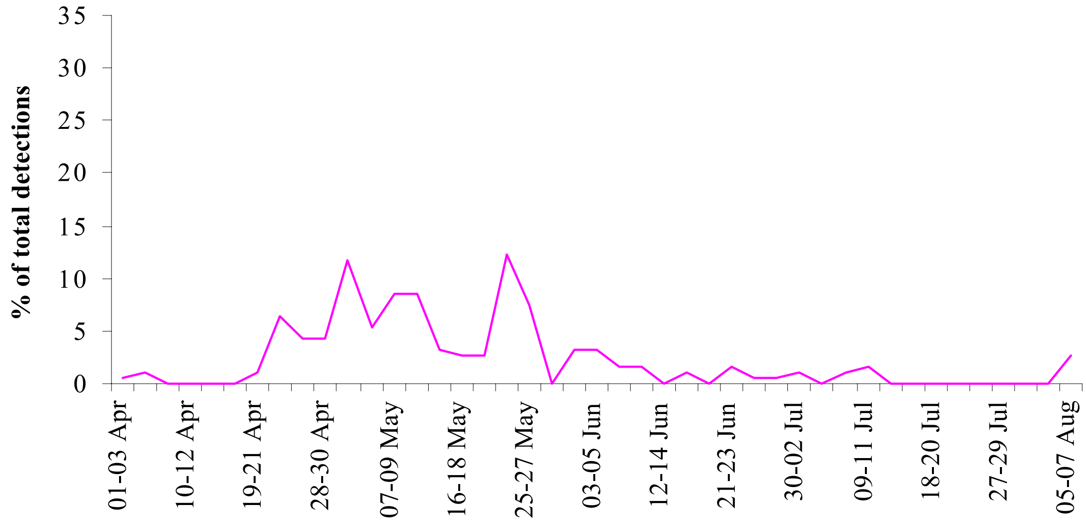


Figure 3. The migration timing (expanded by estimated detection probabilities) at Lower Granite Dam in 1998 of wild spring/summer chinook salmon smolts from individual streams in Idaho and Oregon PIT tagged during late summer 1997.

SOUTH FORK SALMON RIVER



SECESH RIVER

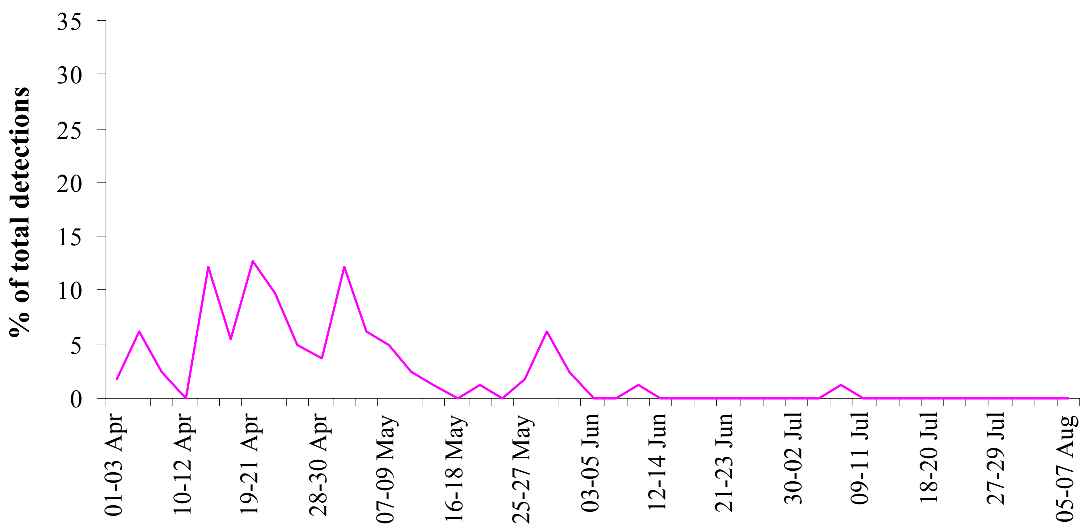
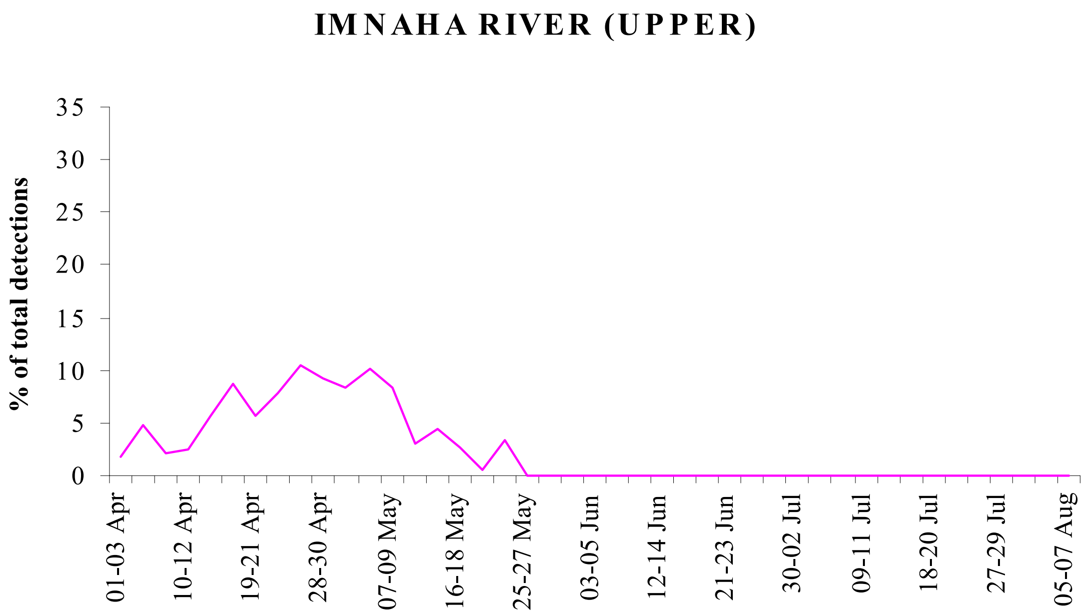


Figure 3. Continued.



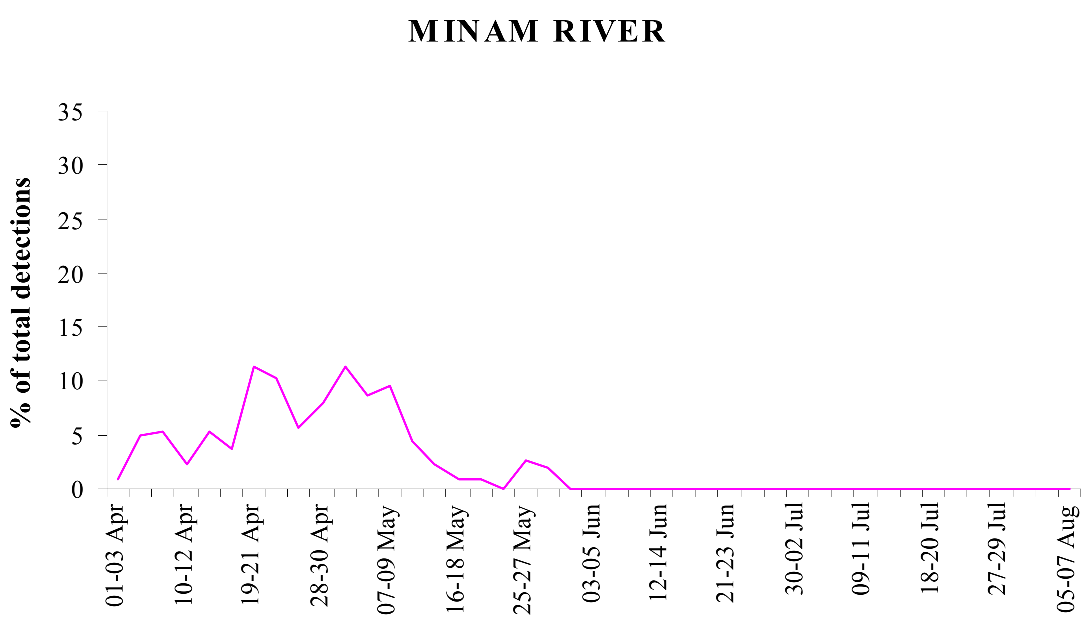


Figure 3. Continued.

Table 5. Historical and 1998 passage dates at Lower Granite Dam for PIT-tagged wild spring/summer chinook salmon smolts from streams in Idaho and Oregon.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
	Bear Valley Creek			
1990	19 April	05 May	31 May	11 April-18 July
1991	03 May	20 May	12 June	18 April-23 June
1992	15 April	02 May	24 May	07 April-28 June
1993	29 April	16 May	22 June	22 April-27 July
1994	22 April	06 May	29 May	16 April-15 July
1995	28 April	18 May	12 June	13 April-20 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998	25 April	06 May	23 May	31 March-25 June
	Elk Creek			
1990[a]	--	--	--	--
1991	03 May	20 May	16 June	25 April-24 June
1992	11 April	30 April	28 May	05 April-17 July
1993	02 May	16 May	11 June	21 April-26 June
1994	23 April	04 May	21 May	18 April-09 July
1995	18 April	11 May	05 June	10 April-09 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998	07 April	02 May	15 May	04 April-21 June
	Sulphur Creek			
1990	18 April	30 April	31 May	11 April-27 June
1991[b]	--	--	--	--
1992	16 April	03 May	23 May	10 April-01 June
1993	28 April	16 May	12 June	24 April-28 June
1994[b]	--	--	--	--
1995	02 May	23 May	09 June	11 April-09 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Cape Horn Creek			
1990[b]	--	--	--	--
1991	24 April	16 May	28 May	19 April-06 June
1992	12 April	28 April	30 May	10 April-01 June
1993	08 May	19 May	26 June	05 May-01 July
1994[b]	--	--	--	--
1995	29 April	14 May	19 June	14 April-28 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	—

Table 5. Continued.

	Passage dates at Lower Granite Dam			
Year	10%	50%	90%	Range
			Marsh Creek	
1990	17 April	29 April	31 May	09 April-01 July
1991	26 April	20 May	09 June	17 April-18 June
1992	17 April	07 May	02 June	10 April-13 July
1993	29 April	15 May	27 May	24 April-10 August
1994	23 April	04 May	18 May	16 April-08 August
1995	17 April	09 May	24 May	11 April-08 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
			Valley Creek	
1989	24 April	14 May	12 June	09 April-17 June
1990	16 April	08 May	05 June	12 April-29 June
1991	11 May	20 May	20 June	21 April-13 July
1992	15 April	30 April	27 May	13 April-04 June
1993	30 April	16 May	02 June	24 April-06 June
1994	24 April	04 May	03 June	22 April-09 June
1995	04 May	02 June	08 July	22 April-18 July
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	—
			Camas Creek	
1993	03 May	16 May	27 May	24 April-24 June
1994	30 April	15 May	26 May	24 April-11 July
1995	27 April	12 May	05 June	17 April-11 June
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
			Loon Creek	
1993	05 May	12 May	17 May	03 May -25 June
1994	29 April	10 May	24 May	22 April-07 June
1995	23 April	11 May	28 May	13 April-07 June
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
			East Fork Salmon River	
1989	22 April	03 May	18 May	07 April-08 June
1990[b]	--	--	--	--
1991	22 April	09 May	26 May	16 April-20 June
1992	13 April	21 April	16 May	10 April-03 June
1993	25 April	06 May	18 May	22 April-01 June
1994	22 April	28 April	17 May	20 April-25 May
1995	14 April	28 April	10 May	11 April-27 May

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
	East Fork Salmon River (continued)			
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Herd Creek			
1992	14 April	20 April	10 May	13 April-18 May
1993	26 April	30 April	18 May	26 April-31 May
1994[a]	--	--	--	--
1995	18 April	03 May	14 May	11 April-28 May
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	South Fork Salmon River			
1989	25 April	13 May	14 June	16 April-20 June
1990[b]	--	--	--	--
1991	20 April	16 May	10 June	17 April-13 July
1992	14 April	29 April	27 May	07 April-27 July
1993	29 April	16 May	02 June	26 April-28 June
1994	27 April	15 May	28 June	22 April-09 July
1995	20 April	10 May	10 June	13 April-13 July
1996	19 April	15 May	09 June	19 April-03 July
1997	13 April	28 April	12 June	07 April-15 June
1998	25 April	12 May	15 June	02 April-07 August
	Big Creek (upper)			
1990	27 April	30 May	22 June	17 April-18 July
1991	18 May	10 June	26 June	26 April-01 July
1992	22 April	08 May	03 June	15 April-26 June
1993	08 May	18 May	26 May	26 April-15 June
1994	03 May	19 May	19 July	25 April-30 August
1995	05 May	23 May	09 June	02 May-26 June
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Big Creek (lower)/Rush Creek			
1993	24 April	29 April	13 May	21 April-16 May
1994	23 April	29 April	11 May	21 April-15 June
1995	19 April	01 May	14 May	11 April-05 June
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	—

Table 5. Continued.

Year	Passage dates at Lower Granite Dam 10%	50%	90%	Range
	West Fork Chamberlain Creek			
1992[c]	15 April	26 April	03 June	12 April-24 June
1993	28 April	15 May	23 June	23 April-22 July
1994[c]	24 April	01 May	05 July	24 April-04 September
1995[c]	16 April	09 May	20 June	12 April-22 September
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Secesh River			
1989	20 April	27 April	09 June	09 April-19 July
1990	14 April	22 April	07 June	10 April-13 July
1991	20 April	27 April	14 June	13 April-20 July
1992	13 April	29 April	04 June	05 April-03 July
1993	26 April	16 May	16 June	22 April-15 July
1994	22 April	26 April	11 July	21 April-07 August
1995	14 April	01 May	24 May	10 April-10 July
1996	14 April	25 April	29 May	12 April-15 July
1997	10 April	18 April	04 May	04 April-11 July
1998	08 April	24 April	28 May	03 April-06 July
	Lake Creek			
1989	23 April	02 May	16 June	12 April-01 July
1990[b]	--	--	--	--
1991[b]	--	--	--	--
1992[b]	--	--	--	--
1993	23 April	09 May	22 June	22 April-25 June
1994	21 April	28 April	19 May	20 April-24 June
1995	17 April	10 May	10 June	14 April-20 July
1996	15 April	21 April	19 May	15 April-02 June
1997	11 April	25 April	02 July	07 April-22 September
1998	04 April	25 April	26 May	02 April-16 July
	Catherine Creek			
1991	01 May	14 May	08 June	17 April-23 June
1992	16 April	01 May	21 May	09 April-29 June
1993	06 May	18 May	05 June	29 April-26 June
1994	25 April	11 May	20 May	13 April-26 July
1995	01 May	19 May	09 June	26 April-02 July
1996[e]	19 April	13 May	29 May	14 April-14 June
1997	08 May	14 May	01 June	24 April-10 June
1998	28 April	21 May	28 May	24 April-04 June

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
	Grande Ronde River (upper)			
1989	12 May	06 June	19 June	27 April-22 July
1990[b]	--	--	--	--
1991[b]	--	--	--	--
1992[b]	--	--	--	--
1993	05 May	16 May	25 May	23 April-20 June
1994	28 April	23 May	07 July	23 April-29 August
1995	27 April	29 May	12 June	12 April-01 July
1996[d]	26 April	17 May	29 May	19 April-06 June
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Imnaha River (lower)			
1989	11 April	30 April	11 May	04 April-05 June
1990	10 April	18 April	09 May	05 April-27 May
1991	20 April	01 May	13 May	14 April-15 May
1992	10 April	21 April	03 May	06 April-21 May
1993[b]	--	--	--	--
1994[b]	--	--	--	--
1995[b]	--	--	--	--
1996[b]	--	--	--	--
1997[b]	--	--	--	--
1998[b]	--	--	--	--
	Imnaha River (upper)			
1993	24 April	14 May	28 May	15 April-23 June
1994	24 April	08 May	09 June	20 April-11 August
1995	13 April	02 May	03 June	10 April-07 July
1996	16 April	26 April	18 May	14 April-12 June
1997	11 April	19 April	11 May	03 April-02 June
1998	11 April	28 April	13 May	03 April-24 May
	Lostine River			
1990[a]	--	--	--	--
1991	29 April	14 May	26 May	20 April-09 July
1992	16 April	30 April	11 May	12 April-02 June
1993	23 April	03 May	17 May	17 April- 01 June
1994	22 April	30 April	16 May	19 April- 07 June
1995	12 April	02 May	17 May	08 April-09 June
1996	23 April	15 May	07 June	17 April-19 June
1997	17 April	28 April	16 May	09 April-21 May
1998[b]	--	--	--	--

[a] Insufficient numbers detected to estimate timing.
[b] No summer-tagged parr were tagged for this migration year.
[c] Includes fish from Chamberlain Creek.
[d] All fish tagged at traps in fall or spring for this migration year.
[e] Includes fish tagged from summer 1995 through spring 1996.

Environmental Information

River Flow

We combined all detections of wild fish from Idaho streams at each of four interrogation dams and compared the timing at each dam with river flows during the same periods (Fig. 4). Overall, passage occurred between late March and early August at Lower Granite Dam, with the middle 80% passage occurring from mid-April to late-May (Table 6).

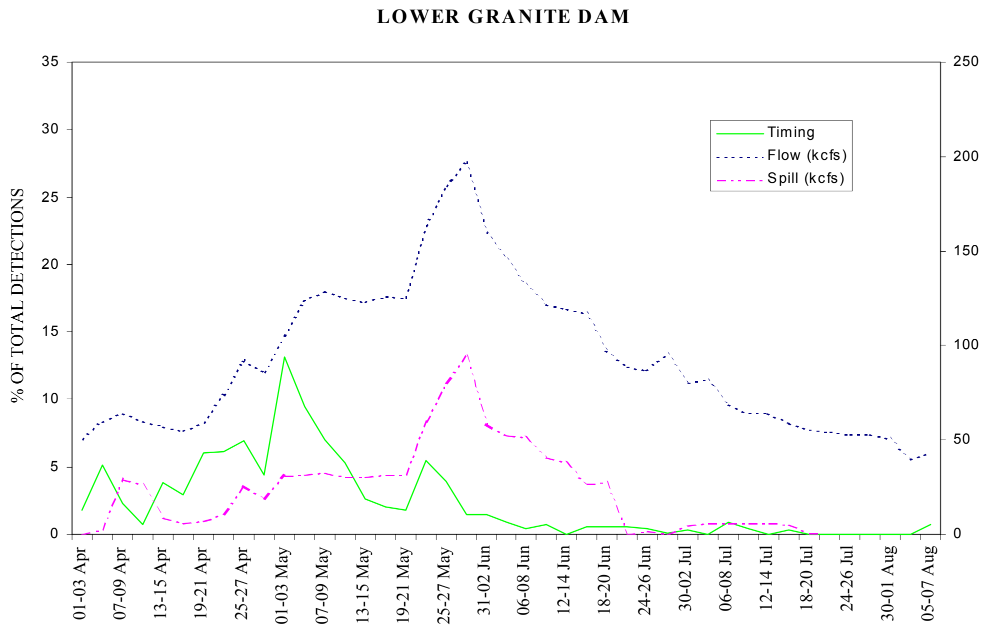
The peak passage date was 3 May, which coincided with increasing, but not peak, flows at the dam (Appendix Table 9). The middle 80% passage of wild fish occurred between late April and early June at Little Goose, Lower Monumental, and McNary Dams (Table 6).

Peak passage periods for fish at Little Goose, Lower Monumental, and McNary Dams coincided with medium-to-high river flows on various dates throughout April and May (Fig. 4 and Appendix Tables 10-12). Passage distributions for fish at John Day and Bonneville Dams are presented in Table 6 and Appendix Tables 4-8; however, too few wild fish were detected at these dams to make meaningful comparisons with flow or other variables. Appendix Table 13 provides a summary of flow information at five USGS sites in the Salmon River drainage from August 1997 to July 1998.

Water Quality Parameters

Appendix Figures 1-6 compare various water quality parameters to chinook salmon fry, parr, and smolt movements through adjacent traps (Fig. 1) in 1997-1998.

Appendix Tables 14-18 provide a summary of environmental information collected from the five environmental monitoring sites (Marsh Creek, Valley Creek, Sawtooth Hatchery, Knox Bridge, and Secesh River) from August 1997 to July 1998. Environmental data collected at these sites are available on the internet (Perkins 1998).



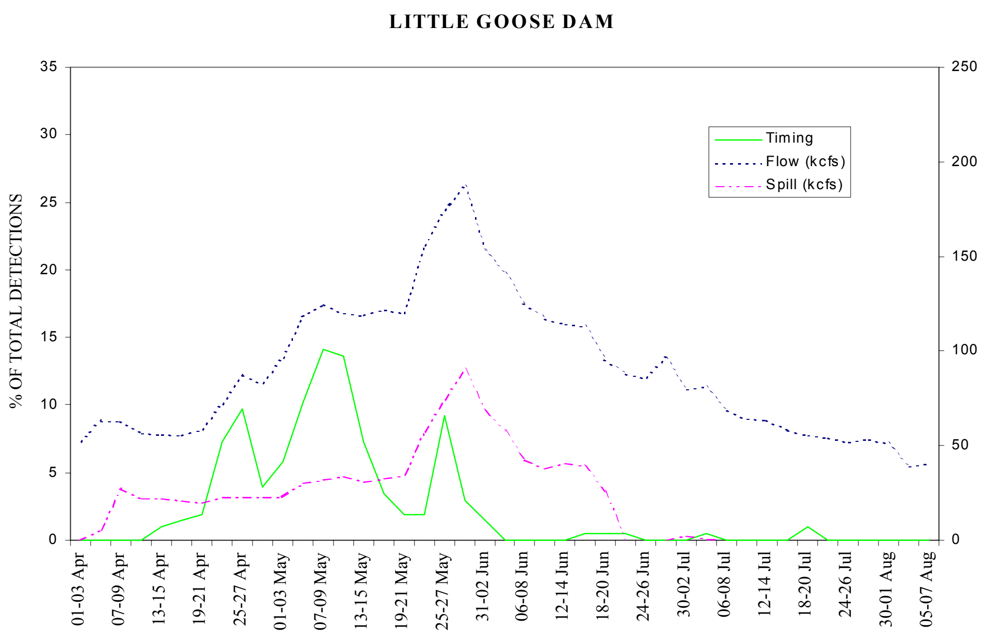
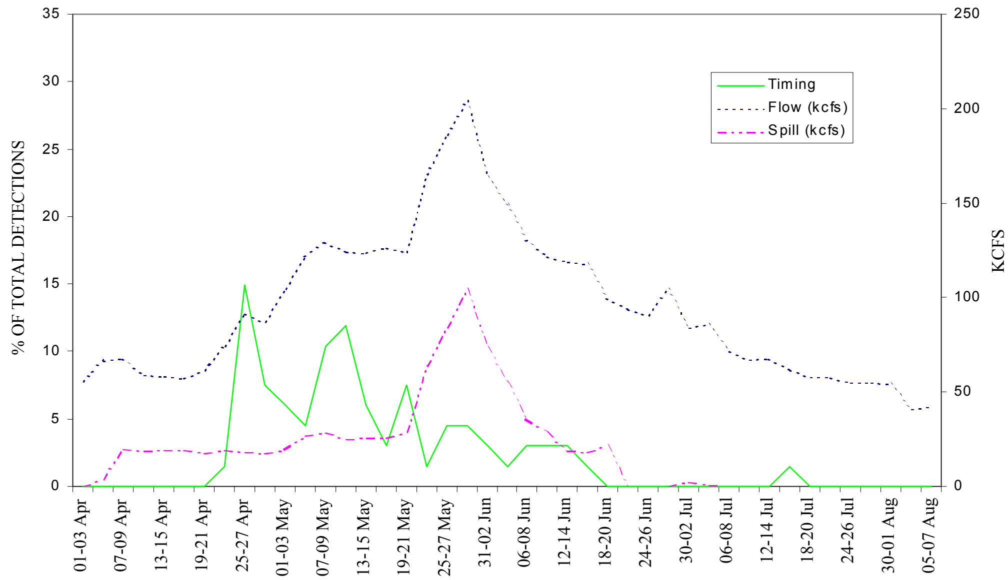


Figure 4. The overall migration timing of PIT-tagged wild spring/summer chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams in 1998, with associated river flows and spill at these dams. Data represent detections from five Idaho streams combined by 3-day intervals and average river flows and spill at the dams over the same time periods. Detections were expanded by estimated daily detection probabilities at Lower Granite Dam only.

LOWER MONUMENTAL DAM



MCNARY DAM

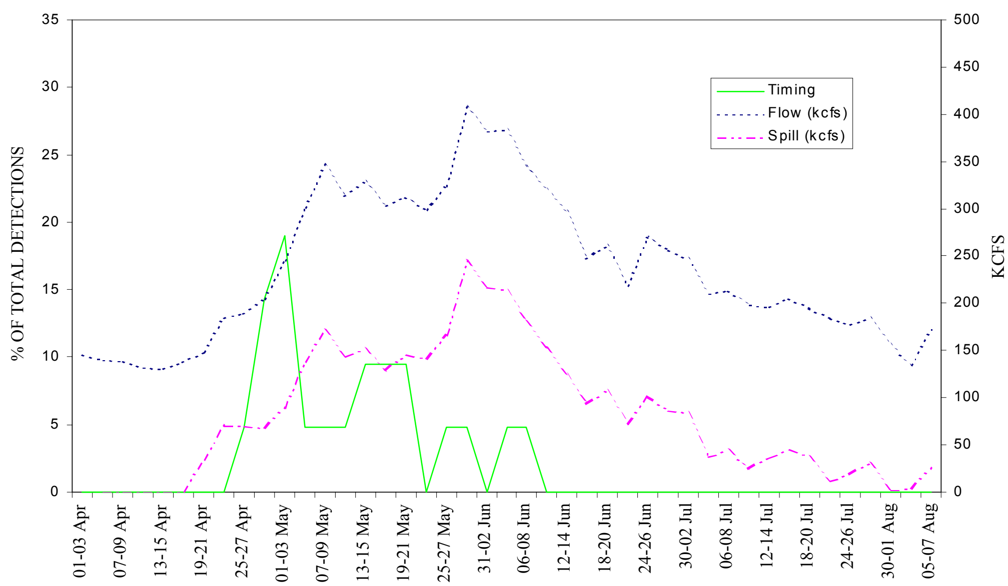


Figure 4. Continued.

Table 6. Passage dates at Lower Granite (expanded), Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams for combined populations of PIT-tagged wild spring/summer chinook salmon smolts from five streams in Idaho in 1998.

	Passage periods at dams			
Site	10%	50%	90%	Range
Lower Granite Dam	13 Apr	03 May	27 May	31 Mar-07 Aug
Little Goose Dam	24 Apr	08 May	26 May	13 Apr-20 July
Lower Monumental Dam	26 Apr	11 May	08 Jun	24 Apr-15 July
McNary Dam	28 Apr	10 May	28 May	27 Apr-06 Jun
John Day Dam	11 May	02 Jun	14 Jun	1 May-12 Aug
Bonneville Dam	07 May	20 May	08 Jun	07 May-14 Jun

DISCUSSION

Mortality rates associated with collection and tagging in 1997 were comparable to those in earlier years (Achord et al. 1992; 1994; 1995a,b; 1996a,b; 1997; 1998).

Of the 72 wild PIT-tagged fish released in summer and detected in fall at the South Fork of the Salmon River trap at Knox Bridge, 22 (30.6%) were detected the next spring at the dams. This detection rate was 83.2% higher than the overall detection rate at the dams (not adjusted) for fish tagged in summer at the South Fork Salmon River (16.7%). We observed a similar pattern at Marsh Creek in 1994-1995 (Achord et al. 1996a), where wild PIT-tagged fish released during summer and detected at Marsh Creek trap during fall had a detection rate at the dams that was 75.7% higher than the overall detection rate of their cohorts.

These high detection rates at the dams for PIT-tagged fish previously detected at traps in the fall may indicate a higher survival rate for known fall migrants and/or may reflect mortality in the stream from summer to fall (over averages of 51 days in 1994 and 30.7 days in 1997). In both of these years, fish detected at the South Fork of the Salmon River and Marsh Creek traps were the same average length at release as fish detected at traps in the fall. This implies that size at tagging had little, if any, effect on post-tagging mortality after release. No survival comparisons from other traps were made due to the low numbers detected at these traps.

Length-distribution curves for data collected over the last 10 years have shown that generally, wild fish released and subsequently detected at dams are slightly larger at release than fish that are released but not detected. The reason for this slight difference in detection rates is unknown, but it appears that larger fish survived slightly better and/or were guided slightly better into the collection systems at the dams than smaller fish. However, if the fish detected at traps in fall at Marsh Creek in 1994 and at the South Fork of the Salmon River in 1997 were a random sample of the population, then survival within the first 1 to 3 months after tagging was not size specific.

Another consistent trend we have observed over the years is the difference in migration timing at dams with respect to size at release. Wild fish migrating in April and May were significantly larger at release than fish migrating after May. This suggests that size is an important factor related to either the initiation of smoltification or other life-history dynamics that affect the migrational timing of wild fish. Additional years of tagging wild fish smaller than 65 mm may provide more definitive answers.

In 1998, overall detection rates of wild fish from four of the five Idaho streams were higher than in previous years at Lower Granite Dam, even without expanding detections for spill or for estimated survival (Matthews et al. 1990, 1992; Achord et al. 1992; 1994; 1995a,b; 1996a; 1997; 1998). Fish from the other Idaho stream, the Secesh River, had only a slightly higher detection rate (not adjusted) at the dam in 1997 (13.1%) than in 1998 (12.6%). The higher detection rates for wild fish in 1998 may have resulted from the mild and wet fall, winter, and spring of 1997-1998. These conditions probably produced less ice-related mortalities during winter, and good flow conditions during spring likely increased survival of these fish.

Detection rates in 1998 were adjusted by expanding detection numbers relative to daily detection probabilities at Lower Granite Dam. This method produced an overall average detection rate of 25.7% for all wild Idaho fish (range 18.6-47.6%, depending on stream of origin). From 1993 to 1997, these rates were calculated using first-time detections at each interrogation dam, which were then expanded relative to the respective daily proportions of spill at each dam. In 1998, this method produced an overall average detection rate of 32.3% (range 23.4-58.5%, depending on stream of origin). For future analyses of migration timing at Lower Granite Dam, we will continue using the detection probability method to expand detection numbers, since it produces more accurate data than expansions based simply on daily spill proportion.

By comparing first-time detections at the dams for wild summer-tagged fish from all eight Idaho and Oregon streams (1,216) to the expanded number of detections at Lower Granite Dam (1,395), we estimated that 12.8% of these fish were not detected at any dam in 1998. This percentage was similar to other estimated proportions of undetected chinook salmon smolts in the same year. Twelve percent of all wild chinook salmon smolts, including those PIT tagged at traps, and 15.0% of all hatchery chinook salmon smolts, were estimated as undetected at the dams in 1998.

Relationships with Flow

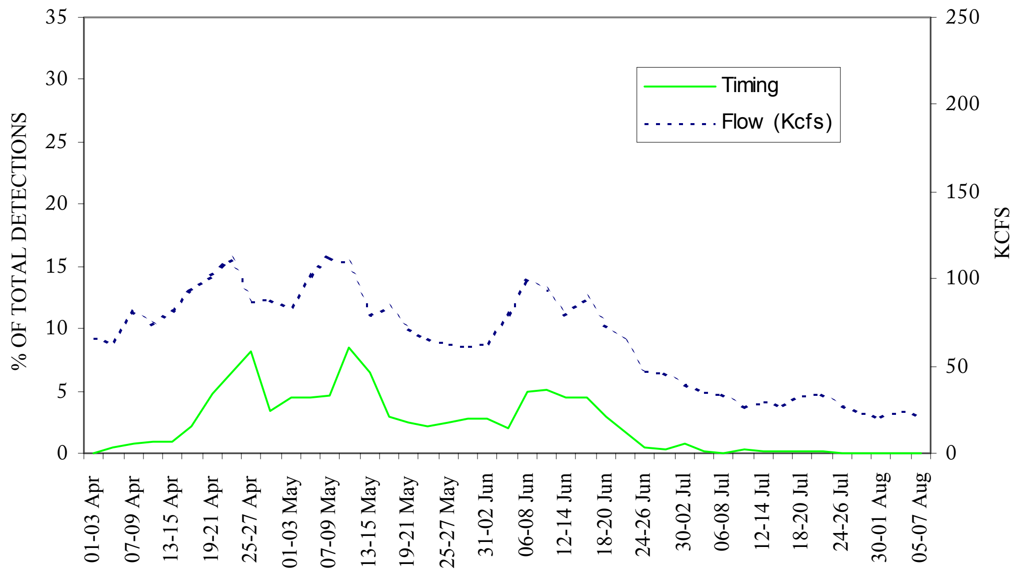
In 1998, peak detections of wild fish (Idaho and Oregon) at Lower Granite Dam coincided with increasing but variable flows in late April and early May (Fig. 5). Gradual increasing flows from a low of 58.2 kcfs on 20 April to 131.3 kcfs on 9 May helped move most of these fish through the dam. As observed at Lower Granite Dam from 1989 through 1997, peak detections of wild spring/summer chinook salmon smolts from Idaho and Oregon were highly variable and generally independent of river flows before about 9 May.

However, in every year peak detections of wild fish from 9 to 31 May coincided with periods of peak flow (Fig. 5). Raymond (1979) showed that peaks in migration for the composite population of spring and summer chinook salmon smolts (mostly wild) passing Ice Harbor Dam from 1964 to 1969 preceded periods of maximum river discharge in most years. During these years, fish passage peaked between 26 April and 13 May. With respect to river flows, our observations matched those of Raymond for wild fish migrating before mid-May.

Climatic Influence

Annual overall climatic variation is emerging as an important factor controlling the overall migrational timing and passage dynamics of wild spring/summer chinook salmon smolts at Lower Granite Dam. Figure 5 provides another perspective on the timing of combined populations (Idaho and Oregon) of wild spring/summer chinook salmon smolts from 1989 through 1998 at Lower Granite Dam.

1989



1990

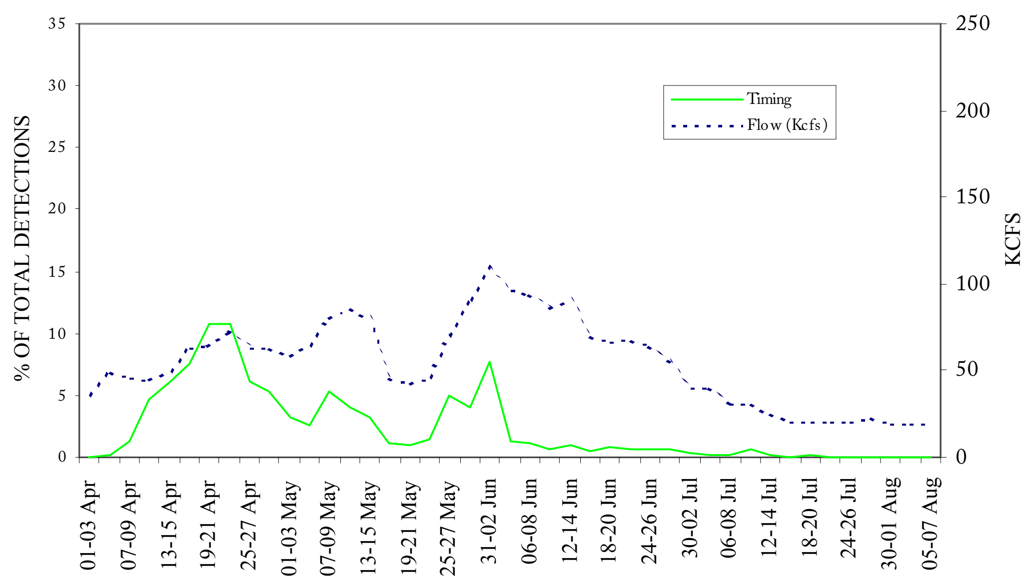
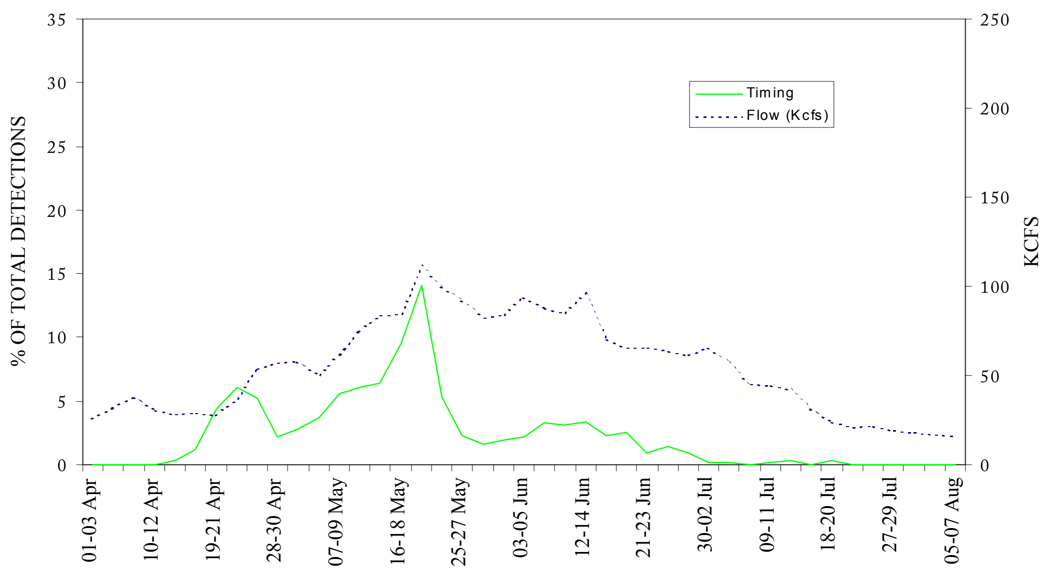


Figure 5. The historical perspective on migration timing (adjusted in spill years) of wild spring/summer chinook salmon smolts at Lower Granite Dam 1989-1998, with associated river flows at the dam. Data represent PIT-tag detections from Idaho and Oregon streams combined by 3-day intervals and average river flows at the dam over the same time periods.

1991



1992

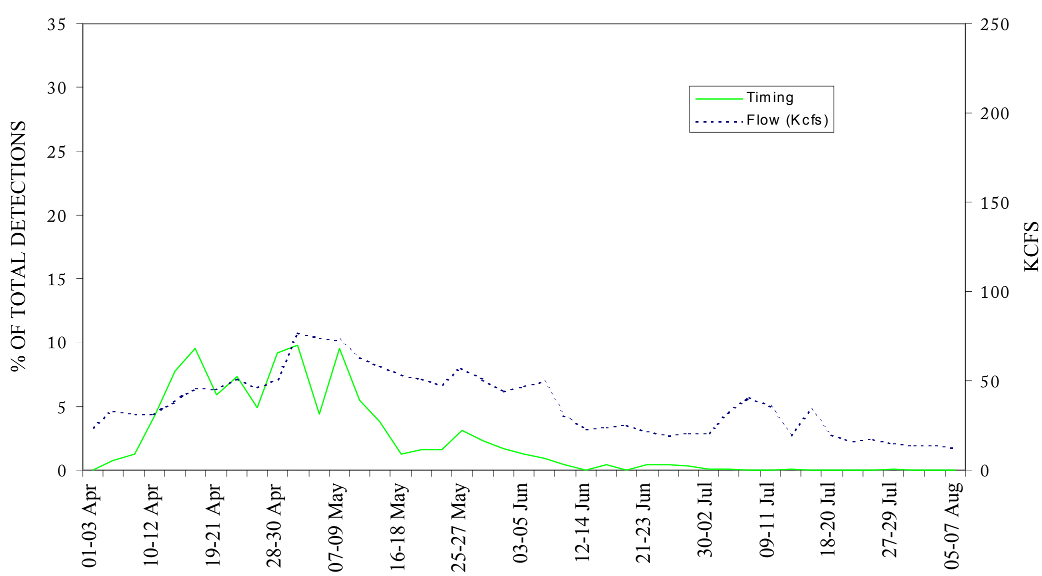
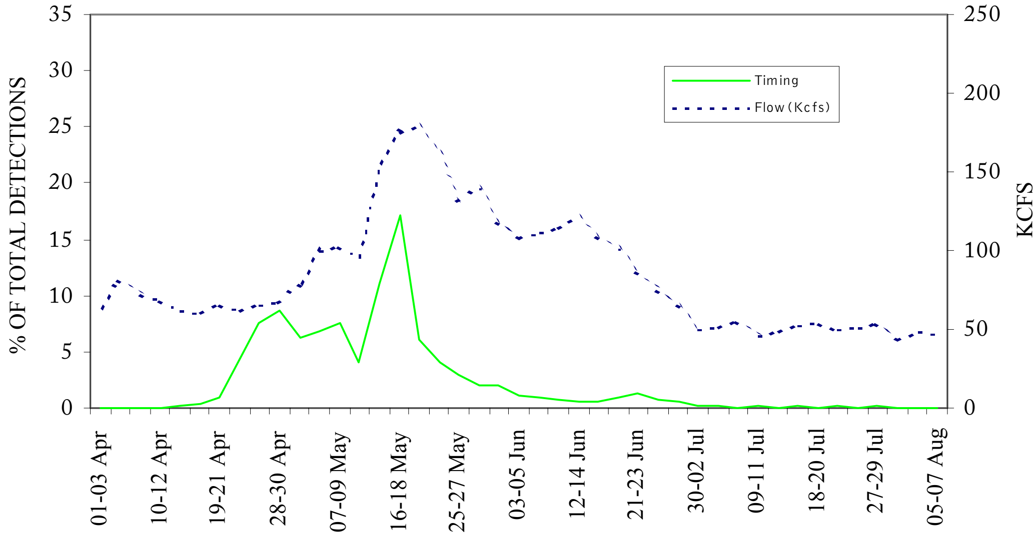


Figure 5. Continued.

1993



1994

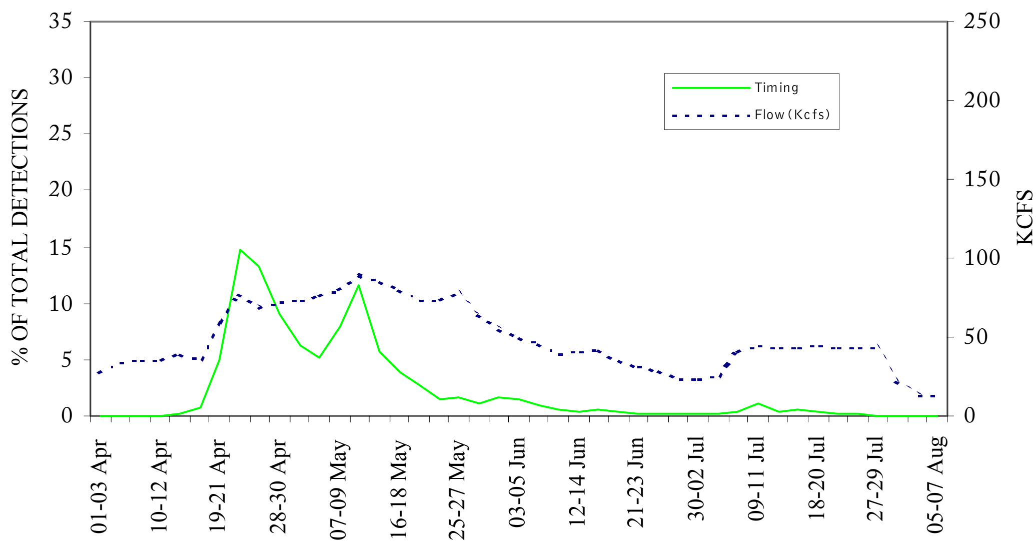
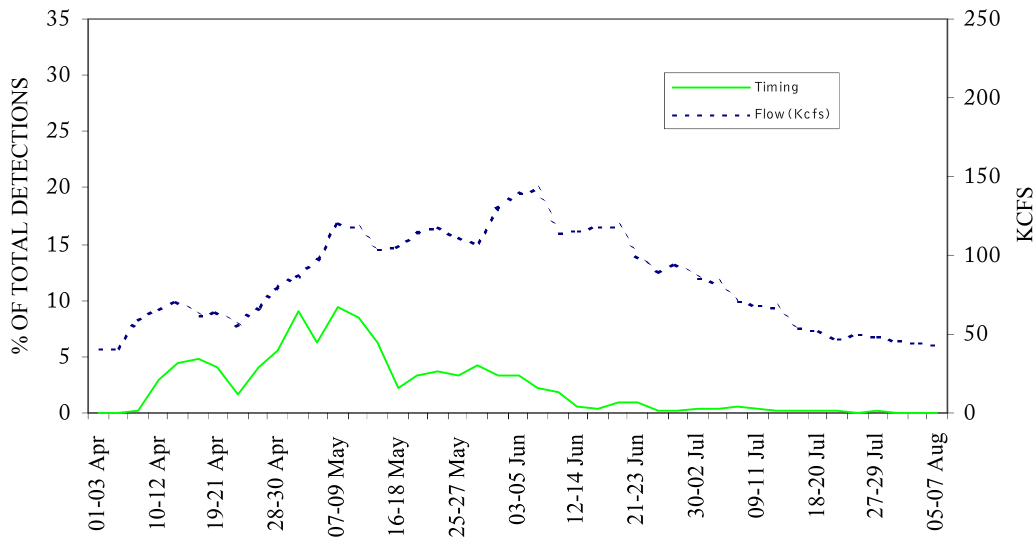


Figure 5. Continued.

1995



1996

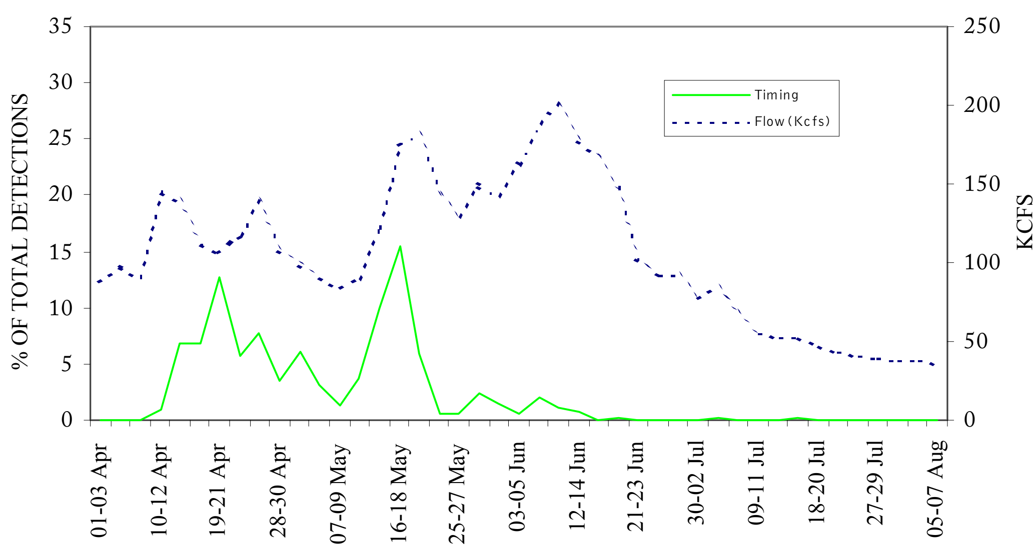
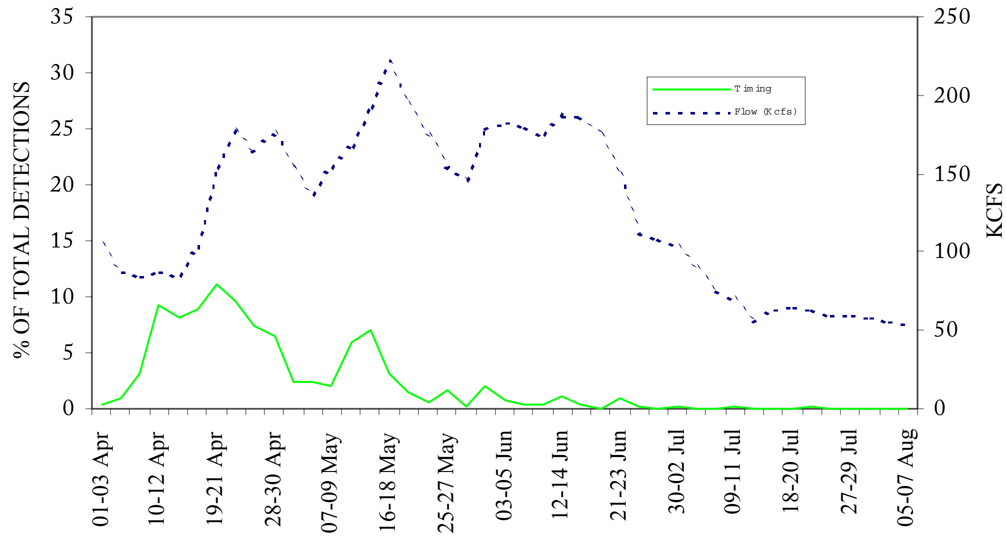


Figure 5. Continued.

1997



1998

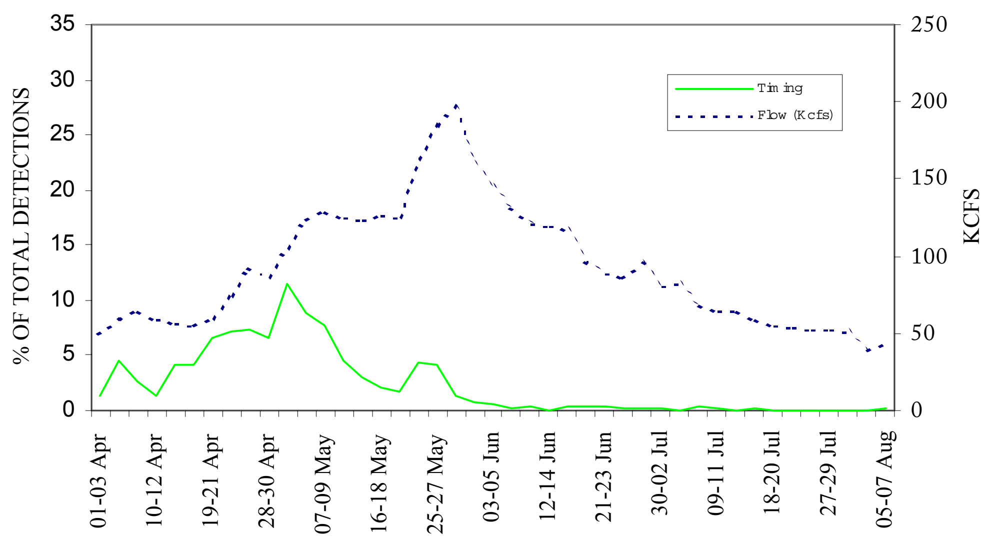


Figure 5. Continued.

In the warm years of 1990, 1992, 1994, and 1998, the median passage date at the dam was between 29 April and 4 May, and 90% of all wild fish passed by the end of May. In the cold years of 1989, 1991, and 1993, median passage did not occur until mid-May, and the 90th percentile had not passed until mid-June (except during high flows in 1993, when the 90th percentile passed by the end of May).

Within these 7 years, we saw a consistent 2- to 3-week shift in timing of wild fish at the dam between relatively warm and relatively cold years. In 1995, intermediate weather conditions prevailed in late winter and early spring (compared to the previous 6 years), and we observed intermediate passage times of 9 May and 5 June for the 50 and 90% passage dates, respectively, for these combined wild populations (Fig. 5).

The migration timing of individual wild stocks has been highly variable and usually protracted at Lower Granite Dam. However, some migration timing patterns emerging for some stocks range from early to late spring. Over all years, the maximum number of days for all stocks have averaged 15.7, 18.2, and 27.3, respectively, for the 10th, 50th, and 90th percentile passage dates. The less than 1- to 5-week passage distribution shifts of these stocks observed over the years appear directly related to annual climatic conditions.

Cumulative Data: 1989-1998

Another objective of this study is to examine the migration timing at Lower Granite Dam of individual stocks over a period of years to determine similarities or differences between years. We now have 9 years of data for South Fork of the Salmon River and 10 years of data for Secesh River fish. The 95% confidence intervals for these data sets fall between 17 and 25 April for the 10th, 5 and 15 May for the 50th, and 4 and 16 June for the 90th percentile passage dates for South Fork of the Salmon River fish. For Secesh River fish, 95% confidence intervals are between 12 and 19 April for the 10th, 22 April and 2 May for the 50th, and 25 May and 16 June for the 90th percentile passage dates. The actual 10th, 50th, and 90th percentile passage date means for these data sets are 21 April, 10 May, and 10 June, respectively, for South Fork Salmon River fish and 16 April, 27 April, and 5 June, respectively, for Secesh River fish.

After examining chinook salmon smolt passage timing at the dams over the last 10 years, it has become clear that flow is only one of several factors that influence passage timing. Other factors, such as annual climatic conditions, water temperature, turbidity, physiological development, variability in stock behavior, fish size, and other yet unknown conditions may equally affect wild smolt passage timing at dams. As additional environmental monitors and traps are installed in study streams, we can more accurately monitor fry, parr, and smolt movements out of rearing areas and examine the relationships between these movements and environmental conditions within the streams. Mapped over time, this information, along with weather and climate data, may prove useful in predicting when different wild stocks will arrive at the first dam.

ACKNOWLEDGMENTS

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REFERENCES

Achord, S., M. B. Eppard, E. E. Hockersmith, B. P. Sandford, and G. M. Matthews. 1997. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1996. Report to Bonneville Power Administration, Project 91-028, Contract DE-AI79-91BP18800. 74 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Achord, S., M. B. Eppard, E. E. Hockersmith, B. P. Sandford, and G. M. Matthews. 1998. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1997. Report to Bonneville Power Administration, Project 91028, Contract DE-AI79-91BP18800. 78 p. (Available on the Internet at www.efw.bpa.gov/cgi-bin/efw/FW/welcome.cgi).

Achord, S., M. B. Eppard, B. P. Sandford, and G. M. Matthews. 1996a. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1995. Report to Bonneville Power Administration, Project 91-028, Contract DE-AI79- 91BP18800. 179 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Achord, S., J. R. Harmon, D. M. Marsh, B. P. Sandford, K. W. McIntyre, K. L. Thomas, N. N. Paasch, and G. M. Matthews. 1992. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1991. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H0034. 57 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Achord, S., D. J. Kamikawa, B. P. Sandford, and G. M. Matthews. 1995a. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1993. Report to Bonneville Power Administration, Project 91-028, Contract DE-AI79- 91BP18800. 88 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Achord, S., D. J. Kamikawa, B. P. Sandford, and G. M. Matthews. 1995b. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1994. Report to Bonneville Power Administration, Project 91-028, Contract DE-AI79- 91BP18800. 100 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Achord, S., G. M. Matthews, O. W. Johnson, and D. M. Marsh. 1996b. Use of Passive Integrated Transponder (PIT) tags to monitor migration timing of Snake River chinook salmon smolts. N. Am. J. Fish. Manage. 16:302-313.

Achord, S., G. M. Matthews, D. M. Marsh, B. P. Sandford, and D. J. Kamikawa. 1994. Monitoring the migrations of wild Snake River spring and summer chinook salmon smolts, 1992. Report to Bonneville Power Administration, Project 91-028, Contract DE-AI79-91BP18800. 73 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, Norwell, MA, 436 p.

Matthews, G. M., S. Achord, J. R. Harmon, O. W. Johnson, D. M. Marsh, B. P. Sandford, N. N. Paasch, K. W. McIntyre, and K. L. Thomas. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1990. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H0034. 51 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle WA 98112-2097.)

Matthews, G. M., J. R. Harmon, S. Achord, O. W. Johnson, and L. A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and related research on the Snake and Columbia Rivers, 1989. Report to U.S. Army Corp of Engineers, Contract DACW68-84-H0034. 59 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle WA 98112-2097.)

Pacific Northwest Electric Power Planning Council and Conservation Act. 1980. Columbia River Basin Fish and Wildlife Program. (Available from Northwest Power Planning Council, 851 SW 6th Avenue, Suite 1100, Portland, OR 97204-1348.)

Perkins, W.A. 1998. Baseline environmental monitoring program: Salmon River Basin. Online interactive database. (Available http://bemdata.nwfsc.noaa.gov/baseline/intro.html)

Petersen, R. G. 1985. Design and analysis of experiments. Marcel Dekker, New York, 429 p.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1990. PIT-tag monitoring systems for hydroelectric dams and fish hatcheries. Am. Fish. Soc. Symp. 7:323-334.

Raymond, H. L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Trans. Am. Fish. Soc. 108(6):505-529.

Sandford, B. P., and S. G. Smith. In prep. Estimation of smolt-to-adult return percentages for Snake River Basin anadromous salmonids, 1990-1997. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA. 98112-2097.)

APPENDIX

Data Tables and Figures

Appendix Table 1. Summary of tagging dates; number collected, tagged, and released; and minimum, maximum, and average lengths and weights of wild chinook salmon parr, PIT tagged in selected Idaho streams in 1997.

Stream	Tagging dates	Number collected	Number tagged	Number released	Length (mm)		Weight (g)	
					Range	Average	Range	Average
S. F. Salmon River	25-26 Aug	1,655	1,009	1,006	52-131	64.0	1.7-11.3	3.3
Secesh River	12-13 Aug	873	592	588	53-81	63.0	1.2- 6.6	3.1
Lake Creek	14 Aug	476	421	418	52-81	63.0	1.6- 7.8	3.5
Bear Valley Creek	18-19 Aug	441	427	427	57-91	75.0	2.1- 8.9	5.9
Elk Creek	21 Aug	253	246	246	64-88	77.0	2.6- 9.5	6.3
Totals or averages	12-26 Aug	3,698	2,695	2,685	52-131	66.0	1.2-11.3	3.7

Appendix Table 2. A summary of the tagging dates, start tagging times and temperatures (°C), release dates, times, and temperatures, method of capture, distance (in kilometers) from the stream's mouth to the release point, number released, number detected, and percent detected for each tag group at six downstream dams during 1998.

Stream	Tag group	Tagging date	Tagging time	Release date	Release time	Tagging temp. (°C)	Release temp. (°C)	Capture method	Release River Km	Number released	Number detected	Percent detected
S. F. Salmon River	SA97237.SF1	25 Aug	08:01	26 Aug	07:00	8.5	8.0	Shock	112	121	14	11.6
	SA97237.SF2	25 Aug	09:55	25 Aug	14:00	9.0	12.0	Shock	113	284	48	16.9
	SA97238.SF1	26 Aug	08:13	26 Aug	13:10	8.0	12.0	Shock	117	233	47	20.2
	SA97238.SF2	26 Aug	10:58	26 Aug	14:30	11.0	14.0	Shock	121	368	59	16.0
Secesh River	SA97224.SE1	12 Aug	10:42	13 Aug	06:45	9.0	9.0	Shock	25	134	42	31.3
	SA97224.SE2	12 Aug	12:16	13 Aug	07:30	11.5	9.5	Shock	25	122	40	32.8
	SA97225.SE1	13 Aug	07:34	13 Aug	14:30	9.0	12.5	Shock	28	332	72	21.7
Lake Creek	SA97226.LC1	14 Aug	07:26	14 Aug	13:30	8.0	13.0	Shock	2	418	86	20.6
Bear Valley Creek	SA97230.BV1	18 Aug	09:24	19 Aug	06:45	11.0	9.5	Shock	9	110	40	36.4
	SA97231.BV1	19 Aug	10:50	19 Aug	14:35	13.5	15.0	Shock	12	317	89	28.1
Elk Creek	SA97233.EC1	21 Aug	08:14	21 Aug	15:00	11.0	15.5	Shock	2	246	105	42.7

Appendix Table 3. A summary of observed total mortality for PIT-tagged wild chinook salmon parr collected from Idaho streams during August 1997.

Stream	Number collected	Number tagged	Number rejected	Percent rejected (%)	Observed total mortality			
					Collection	Tagging	Total	%
South Fork Salmon River	1,655	1,009	618	38.0	28	3	31	1.9
Secesh River	873	592	246	29.4	35	4	39	4.5
Lake Creek	476	421	52	11.0	3	3	6	1.3
Bear Valley Creek	441	427	1	0.2	13	0	13	2.9
Elk Creek	253	246	0	0.0	7	0	7	2.8
Totals	3,698	2,695	917	25.4	86	10	96	2.6

Appendix Table 4. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from the South Fork of the Salmon River, 1998.

Tagging site: S. F. Salmon River   Release date: 25-26 August 1997
Release site: S. F. Salmon River   Number released: 1,006
Release River Kilometer(s) above Lower Granite Dam: 457- 466

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
02 Apr	1	1					
03 Apr							
06 Apr	1	2					
07 Apr							
19 Apr	1	2					
22 Apr	2	4					
23 Apr	1	2	1				
24 Apr	3	6	1				
25 Apr	2	4					
26 Apr	2	4					
28 Apr	1	2					
29 Apr	2	4		1			
30 Apr	1	2	1				
01 May			2			1	
02 May	2	4		1			
03 May	9	18			1		
04 May							
05 May	2	4		1			
06 May	3	6	1				
07 May	1	2	3				1
08 May	3	6					
09 May	4	8	2				
10 May	2	4	2				
11 May	4	8	2				
12 May	2	4	3	2			
13 May	2	4	1	1			
14 May	1	2	2	1	2		
15 May							
16 May			2				
17 May				1			
18 May	2	5					
19 May	1	2	1	1			

Appendix Table 4. Continued.

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
20 May			1		1		
21 May	1	3		1	1		
22 May	5	14				1	
23 May	2	6	1	1			
24 May	1	3	1				1
25 May	2	6	2				
26 May			6				
27 May	2	8	3	2			
28 May			3	1			
29 May			1	1			
30 May			2				
31 May	1	6	2	1			1
01 Jun						1	
02 Jun						2	
04 Jun	1	3					
05 Jun	1	3					
06 Jun							
08 Jun	1	3		1			
09 Jun	1	3		1			
10 Jun							
11 Jun				1			
13 Jun				1			
14 Jun				1		1	1
15 Jun	1	2					
16 Jun				1			
21 Jun	1	1					
22 Jun	1	1					
23 Jun	1	1					
24 Jun							
26 Jun	1	1					
27 Jun							
29 Jun	1	1					
02 Jul	1	2					
05 Jul			1				
08 Jul	1	2					
11 Jul	1	3					
19 Jul			1				
07 Aug	1	5					
Totals	83	187	48	22	5	6	4

Appendix Table 5. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from the Secesh River, 1998.

Tagging site: Secesh River Release date: 12-13 August 1997
Release site: Secesh River Number released: 588
Release River Kilometer(s) above Lower Granite Dam: 429-431

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
3 Apr	2	3					
4 Apr	5	10					
5 Apr							
7 Apr	1	2					
8 Apr	1	2					
13 Apr		3					
14 Apr	4	11					
15 Apr	2	6					
16 Apr							
17 Apr	1	2					
18 Apr	3	7	2				
19 Apr	1	2					
20 Apr	1	2					
21 Apr	8	17	1				
22 Apr	2	4	2				
23 Apr	5	10	2				
24 Apr	1	2	3				
25 Apr			2	1			
26 Apr	2	4	3	3			
27 Apr	2	4	3	1	1		
28 Apr	1	2	1	1	1		
29 Apr	2	4	1		1		
30 Apr							
01 May	3	6	1				
02 May	5	10	1				
03 May	2	4	2				
04 May	1	2	3		1		
05 May	1	2		1			
06 May	3	6	4				

Appendix Table 5. Continued.

Detection date	Lower Granite		First Detections				
	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
07 May			4				
08 May	1	2	1	1			
09 May	3	6	1	1			
10 May			1		1		
11 May	1	2		1		1	
12 May	1	2	2	1			
13 May			1				
14 May	1	2	1				
15 May				1			
16 May			1				
17 May			2				
18 May							
19 May	1	2					
20 May			1				1
21 May							
23 May			1				
24 May						1	
25 May	1	3	1				
26 May			2				
28 May	2	10					
29 May							
31May						1	
01 Jun				1			
02 Jun	1	4					
03 Jun							
06 Jun					1		
7Jun				1			
08 Jun							1
09 Jun						1	
11 Jun	1	2					
16 Jun			1				
18 Jun			1				
06 Jul	1	2					
20 Jul							
12 Aug						1	
Totals	73	164	52	14	6	5	2

Appendix Table 6. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Lake Creek, 1998.

Tagging site: Lake Creek Release date: 14 August 1997
Release site: Lake Creek Number released: 418
Release River Kilometer(s) above Lower Granite Dam: 451-452

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
02 Apr	2	3					
03 Apr	3	5					
04 Apr	3	6					
05 Apr	2	5					
06 Apr	1	2					
07 Apr	1	2					
10 Apr	2	5					
14 Apr			1				
16 Apr	1	3	1				
17 Apr	1	2					
18 Apr	1	2					
19 Apr	1	2	1				
20 Apr	1	2					
21 Apr			2				
22 Apr	2	4					
23 Apr	1	2					
24 Apr	1	2	1				
25 Apr	4	7	3				
26 Apr	2	4	2	1			
27 Apr	1	2	1	1			
28 Apr	2	4	3				
29 Apr	1	2					
30 Apr			1				
01 May	1	2	1		1		
02 May	1	2	1				
03 May	1	2	1		1		
04 May	2	4	1				

Appendix Table 6. Continued.

Detection date	Lower Granite First detected	Expanded	First Detections Little Goose	Lower Monumental	McNary	John Day	Bonneville
05 May	1	2					
06 May			1				
07 May			2				
08 May	1	2					
09 May	1	2					
10 May			1	2			
11 May			1				
12 May			1				
13 May	1	2					
17 May				1			
19 May				1			
22 May	1	3					
26 May	1	4					
01 Jun			1				
04 Jun				1	1		
05 Jun						1	
06 Jun							
19 Jun	1	2					
25 Jun	1	1					
07 Jul	1	2					
16 Jul	1	2					
Total	48	98	27	7	3	1	0

Appendix Table 7. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Bear Valley Creek, 1998.

Tagging site: Bear Valley Creek   Release date: 18-19 August 1997
Release site: Bear Valley Creek   Number released: 427
Release River Kilometer(s) above Lower Granite Dam: 628-631

Detection date	Lower Granite First detected	Lower Granite Expanded	First Detections Little Goose	Lower Monumental	McNary	John Day	Bonneville
31 Mar	1	1					
14 Apr	1	3					
17 Apr	1	2					
20 Apr	1	2					
21 Apr	1	2					
22 Apr			1				
23 Apr			1				
24 Apr	1	2	1				
25 Apr	1	2	1				
26 Apr	1	2					
27 Apr	2	4	1				
28 Apr	1	2		2	1		
29 Apr	2	4					
30 Apr	1	2		1			
01 May	2	4					
02 May	7	14		2			
03 May	3	6	1		1		
04 May	3	6	1				
05 May	1	2					
06 May	5	11	5				
07 May	3	6	1				
08 May			6	2			1
09 May	2	4	3				
10 May	3	6	5				
11 May			6	1			
12 May	2	4	3	1			
13 May	2	4	2				
14 May	1	2	3				
15 May	1		4				

Appendix Table 7. Continued.

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
16 May			1				
18 May	2	5	1				
19 May	1	2		1			1
20 May							
21 May	1	3					
22 May	1	3				1	
23 May	1	3					
24 May	1	3					
25 May	2	6					
26 May			2		1		
31 May						1	
02 Jun						1	
10 Jun						1	
11 Jun						1	
18 Jun	1	2					
25 Jun	1	1					
15 Jul				1			
Totals	60	125	49	11	3	5	2

Appendix Table 8. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Elk Creek, 1998.

Tagging site: Elk Creek Release date: 21 August 1997
Release site: Elk Creek Number released: 246
Release River Kilometer(s) above Lower Granite Dam: 635-636

	Lower Granite		First Detections				
Detection date	First detected	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
04 Apr	3	6					
05 Apr	1	2					
06 Apr	1	2					
07 Apr	2	5					
08 Apr	1	2					
09 Apr	1	3					
13 Apr			1				
14 Apr	1	3					
17 Apr	1	2					
19 Apr	1	2					
20 Apr	3	6					
21 Apr	1	2					
22 Apr	1	2					
23 Apr	1	2	1				
24 Apr			1	1			
25 Apr	3	6	1	3			
26 Apr	1	2	1				
27 Apr	1	2	2				
29 Apr	1	2					
30 Apr			1				
01 May	2	4					
02 May	2	4	2	1			
03 May	5	10					
04 May	5	10	3				
05 May	3	6	1				
06 May	2	4	1	1			
07 May	2	4	3				
08 May	1	2		1			
09 May	2	4	3	2	1		

Appendix Table 8. Continued.

Detection date	Lower Granite First detected	Lower Granite Expanded	First Detections Little Goose	Lower Monumental	McNary	John Day	Bonneville
10 May	1	2					
11 May	1	2					1
12 May	1	2	1				
13 May			1				
15 May	1	2		1			
16 May	1	2					
17 May	1	2			1		
18 May					1		
19 May			1	1			
20 May							
22 May	1	3					
24 May			1				
25 May			1				
26 May			2				
27 May				1			
28 May					1		
29 May				1			
08 Jun						1	
16 Jun	1	2					
21 Jun	1	1					
23 Jun			1				
Totals	57	117	29	13	4	1	1

Appendix Table 9. Daily and expanded detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Granite Dam during 1998, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
31 Mar				1	1
02 Apr	53.4	0.0	7.9	3	4
03 Apr	53.8	0.0	8.1	5	8
04 Apr	55.6	0.0	8.3	11	22
05 Apr	58.2	0.0	8.6	3	7
06 Apr	64.4	7.6	8.7	3	6
07 Apr	68.7	29.1	8.8	4	9
08 Apr	63.0	28.9	9.1	2	4
09 Apr	61.3	28.9	9.5	1	3
10 Apr	60.2	28.2	9.6	2	5
11 Apr	60.7	25.1	9.4	0	0
12 Apr	58.4	25.1	9.4	0	0
13 Apr	58.4	15.5	9.7	1	3
14 Apr	55.5	5.7	9.8	6	17
15 Apr	57.3	5.9	9.7	2	6
16 Apr	55.8	6.0	9.5	1	3
17 Apr	55.4	6.0	9.4	4	8
18 Apr	53.5	6.0	9.7	4	9
19 Apr	52.8	6.0	9.6	4	8
20 Apr	58.2	6.0	10.2	6	12
21 Apr	64.7	9.5	10.7	10	21
22 Apr	62.5	6.7	11.0	7	14
23 Apr	71.4	6.5	10.9	8	16
24 Apr	86.0	19.0	11.1	6	12
25 Apr	98.6	32.1	11.4	10	19
26 Apr	93.6	26.7	11.2	8	16
27 Apr	84.1	17.3	10.6	6	12
28 Apr	82.1	15.4	10.5	5	10
29 Apr	83.6	16.8	10.8	8	16
30 Apr	90.8	24.0	11.2	2	4
01 May	100.8	34.0	11.3	8	16
02 May	102.2	31.3	--	17	34

Appendix Table 9. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
03 May	111.7	26.7	--	20	40
04 May	119.3	31.3	--	11	22
05 May	124.5	31.0	12.6	8	16
06 May	126.7	32.9	12.4	13	27
07 May	126.6	31.3	12.4	6	12
08 May	128.9	32.5	12.4	6	12
09 May	131.3	34.7	12.3	12	24
10 May	129.8	33.1	12.1	6	12
11 May	123.7	29.2	11.8	6	12
12 May	122.5	29.2	12.5	6	12
13 May	125.4	29.3	12.5	5	10
14 May	117.3	29.2	12.3	3	6
15 May	127.0	32.4	12.0	1	2
16 May	123.7	29.3	11.8	1	2
17 May	126.0	29.2	11.9	1	2
18 May	127.9	36.5	12.2	4	10
19 May	127.5	30.5	12.6	3	6
20 May	125.5	32.3	13.1	0	0
21 May	122.6	31.9	13.3	2	6
22 May	143.6	42.0	13.3	8	23
23 May	172.6	68.4	12.5	3	9
24 May	173.5	68.8	11.8	2	6
25 May	161.5	57.1	11.7	5	15
26 May	178.0	73.4	11.8	1	4
27 May	213.3	109.4	11.6	2	8
28 May	209.0	105.8	11.6	2	10
29 May	191.9	88.1	11.9	0	0
30 May	189.5	88.8	12.4	0	0
31 May	167.5	64.9	13.0	1	6
01 Jun	162.6	59.7	13.1	0	0
02 Jun	149.0	49.8	13.8	1	4
03 Jun	150.7	58.0	14.2	0	0
04 Jun	142.0	43.4	14.5	1	3
05 Jun	144.1	56.4	14.1	1	3
06 Jun	139.2	53.1	14.3	0	0

Appendix Table 9. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
07 Jun	131.2	58.0	14.0	0	0
08 Jun	125.6	42.9	14.3	1	3
09 Jun	126.6	39.3	14.5	1	3
10 Jun	121.1	49.3	14.6	0	0
11 Jun	117.2	33.7	15.5	1	2
12 Jun	114.6	34.4	15.4	0	0
13 Jun	120.4	40.2	15.4	0	0
14 Jun	122.7	38.1	15.5	0	0
15 Jun	119.4	28.2	15.5	1	2
16 Jun	116.6	25.3	15.7	1	2
17 Jun	115.2	27.3	15.7	0	0
18 Jun	97.6	27.2	14.9	1	2
19 Jun	94.3	27.4	14.8	1	2
20 Jun	99.6	27.1	15.9	0	0
21 Jun	91.6	0.0	16.3	2	2
22 Jun	89.0	0.0	15.9	1	1
23 Jun	84.2	0.0	15.8	1	1
24 Jun	86.0	0.0	16.1	0	0
25 Jun	83.1	5.3	16.3	2	2
26 Jun	90.7	0.0	16.2	1	1
27 Jun	101.3	0.0	16.2	0	0
28 Jun	98.0	0.0	15.9	0	0
29 Jun	88.1	0.0	15.8	1	1
30 Jun	85.1	0.0	16.7	0	0
01 Jul	77.5	9.1	17.1	0	0
02 Jul	78.1	5.7	18.3	1	2
03 Jul	79.5	5.8	18.4	0	0
04 Jul	85.4	5.8	18.9	0	0
05 Jul	80.3	5.7	19.2	0	0
06 Jul	72.9	5.7	19.1	1	2
07 Jul	69.2	5.8	20.4	1	2
08 Jul	64.5	5.7	20.4	1	2
09 Jul	63.6	5.7	21.1	0	0
10 Jul	62.8	5.7	21.3	0	0
11 Jul	65.9	5.8	20.9	1	3

Appendix Table 9. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
12 Jul	66.8	5.8	21.0	0	0
13 Jul	61.6	5.8	20.8	0	0
14 Jul	64.0	5.8	20.8	0	0
15 Jul	62.1	5.8	20.4	0	0
16 Jul	58.3	3.8	20.6	1	2
17 Jul	55.9	5.6	21.5	0	0
18 Jul	54.9	1.6	20.5	0	0
19 Jul	54.7	0.0	20.8	0	0
20 Jul	55.7	0.0	21.3	0	0
21 Jul	53.7	0.0	22.0	0	0
22 Jul	54.2	0.0	21.9	0	0
23 Jul	54.7	0.0	21.8	0	0
25 Jul	53.4	0.0	20.9	0	0
26 Jul	52.3	0.0	20.4	0	0
27 Jul	51.0	0.0	22.4	0	0
28 Jul	53.7	0.0	22.3	0	0
29 Jul	54.0	0.0	21.6	0	0
30 Jul	49.8	0.0	22.2	0	0
31 Jul	51.3	0.0	21.2	0	0
01 Aug	50.8	0.0	20.8	0	0
02 Aug	51.2	0.0	20.4	0	0
03 Aug	33.7	0.0	21.0	0	0
04 Aug	34.0	0.0	22.2	0	0
05 Aug	45.3	0.0	22.2	0	0
06 Aug	41.2	0.0	22.1	0	0
07 Aug	42.4	0.0	22.4	1	5
08 Aug	37.6	0.0	21.9	0	0

Appendix Table 10. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Little Goose Dam during 1998, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
01 Apr	44.9	0.0	8.0	0
02 Apr	54.7	0.0	8.0	0
03 Apr	56.4	0.0	7.9	0
04 Apr	57.1	0.0	7.9	0
05 Apr	60.4	0.0	8.0	0
06 Apr	71.0	15.0	8.3	0
07 Apr	74.5	29.8	8.4	0
08 Apr	57.8	28.4	8.6	0
09 Apr	57.4	24.6	8.9	0
10 Apr	56.0	23.0	9.1	0
11 Apr	59.5	22.9	9.2	0
12 Apr	54.8	20.8	9.3	0
13 Apr	54.5	23.1	9.4	1
14 Apr	57.6	23.1	9.6	1
15 Apr	55.6	19.7	9.5	0
16 Apr	55.6	22.0	9.6	1
17 Apr	56.7	22.6	9.7	0
18 Apr	54.2	18.1	9.9	2
19 Apr	51.5	17.0	9.9	1
20 Apr	58.1	19.6	10.2	0
21 Apr	65.9	22.6	11.0	3
22 Apr	61.7	23.1	10.4	3
23 Apr	69.1	22.9	10.7	5
24 Apr	84.7	23.0	10.7	7
25 Apr	94.4	22.9	10.8	7
26 Apr	87.6	22.4	11.5	6
27 Apr	80.4	23.0	12.3	7
28 Apr	81.8	23.0	12.0	4
29 Apr	81.1	22.8	11.9	1
30 Apr	86.0	23.0	11.9	3
01 May	94.7	22.8	11.9	4
02 May	97.0	22.8	11.5	4
03 May	97.0	22.8	11.9	4

Appendix Table 10. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
04 May	114.2	27.4	12.8	8
05 May	119.7	31.8	12.9	1
06 May	120.8	31.3	13.0	12
07 May	122.2	30.2	13.0	13
08 May	125.3	31.7	12.9	7
09 May	126.8	34.8	12.7	9
10 May	124.8	32.5	12.6	9
11 May	118.1	42.6	12.6	9
12 May	116.6	26.8	12.6	10
13 May	124.1	33.5	12.3	5
14 May	112.3	25.1	12.4	6
15 May	120.8	33.4	12.4	4
16 May	120.3	30.0	12.5	4
17 May	120.2	35.2	12.1	2
18 May	125.1	32.8	11.7	1
19 May	122.3	33.0	12.5	2
20 May	121.3	37.2	12.6	2
21 May	115.9	32.4	12.8	0
22 May	138.5	43.6	13.3	0
23 May	162.5	61.9	13.3	2
24 May	166.2	65.6	13.0	2
25 May	155.4	54.7	12.2	4
26 May	167.7	68.3	11.7	12
27 May	200.4	98.4	11.8	3
28 May	197.8	98.3	11.9	3
29 May	183.1	85.2	11.7	1
30 May	179.8	86.9	12.1	2
31 May	163.1	70.9	12.6	2
01 Jun	152.8	65.7	13.1	1
02 Jun	144.1	68.6	13.8	0
03 Jun	146.0	66.1	14.4	0
04 Jun	139.0	52.0	14.9	0
05 Jun	138.7	55.0	14.6	0
06 Jun	131.4	44.8	14.5	0

Appendix Table 10. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
07 Jun	124.4	46.1	14.5	0
08 Jun	119.5	37.2	14.5	0
09 Jun	123.5	39.2	14.6	0
10 Jun	115.3	37.3	14.6	0
11 Jun	112.9	36.4	15.0	0
12 Jun	109.2	34.7	15.3	0
13 Jun	116.4	45.6	15.7	0
14 Jun	116.4	42.1	15.8	0
15 Jun	117.6	53.6	15.7	0
16 Jun	112.9	34.6	15.6	1
17 Jun	108.9	29.2	16.0	0
18 Jun	100.4	28.5	15.9	1
19 Jun	89.7	24.5	15.7	0
20 Jun	96.8	24.8	16.2	0
21 Jun	90.3	0.0	15.6	0
22 Jun	89.0	0.0	16.1	0
23 Jun	85.0	0.0	15.8	1
24 Jun	85.7	0.0	15.8	0
25 Jun	81.8	0.0	15.8	0
26 Jun	90.0	0.0	15.9	0
27 Jun	100.0	0.0	16.2	0
28 Jun	99.3	0.0	16.5	0
29 Jun	89.7	0.0	17.5	0
30 Jun	83.8	0.0	16.7	0
01 Jul	77.4	7.9	16.2	0
02 Jul	78.2	0.0	16.8	0
03 Jul	78.5	0.0	17.1	0
04 Jul	83.9	1.2	17.5	0
05 Jul	81.0	0.0	18.1	1
06 Jul	72.3	0.0	19.1	0
07 Jul	68.9	0.0	20.3	0
08 Jul	64.4	0.0	19.6	0
09 Jul	65.4	0.0	20.3	0
10 Jul	60.7	0.0	20.7	0
11 Jul	66.0	0.0	20.1	0

Appendix Table 10. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
12 Jul	67.3	0.0	20.3	0
13 Jul	60.6	0.0	20.6	0
14 Jul	62.7	0.0	20.8	0
15 Jul	60.7	0.0	21.1	0
16 Jul	58.9	0.0	21.6	0
17 Jul	54.9	0.0	21.3	0
18 Jul	55.4	0.0	20.5	0
19 Jul	53.9	0.0	20.7	1
20 Jul	56.4	0.0	21.2	0
21 Jul	53.8	0.0	21.6	0
22 Jul	52.3	0.0	22.6	0
23 Jul	56.1	0.0	22.2	0
24 Jul	51.3	0.0	21.5	0
25 Jul	53.5	0.0	22.0	0
26 Jul	50.8	0.0	24.0	0
27 Jul	52.8	0.0	23.2	0
28 Jul	53.2	0.0	22.1	0

Appendix Table 11. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Monumental Dam during 1998, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
01 Apr	49.8	0.0	8.3	0
02 Apr	58.0	0.0	8.4	0
03 Apr	59.1	0.0	8.4	0
04 Apr	60.2	0.0	8.3	0
05 Apr	62.4	0.0	8.3	0
06 Apr	77.0	9.8	8.3	0
07 Apr	78.7	19.7	8.3	0
08 Apr	63.1	20.1	8.5	0
09 Apr	61.4	19.7	8.6	0
10 Apr	58.5	19.6	8.9	0
11 Apr	61.9	18.5	9.1	0
12 Apr	55.6	17.8	9.2	0
13 Apr	57.5	19.2	9.2	0
14 Apr	58.2	19.1	9.3	0
15 Apr	59.0	18.6	9.5	0
16 Apr	56.9	19.7	9.6	0
17 Apr	58.6	18.1	9.7	0
18 Apr	55.7	19.1	9.9	0
19 Apr	53.3	15.5	9.9	0
20 Apr	60.3	19.0	10.2	0
21 Apr	69.8	18.2	10.6	0
22 Apr	62.3	19.7	10.6	0
23 Apr	70.3	18.0	10.8	0
24 Apr	88.7	19.6	10.6	1
25 Apr	101.2	18.1	10.6	4
26 Apr	91.4	18.4	11.0	4
27 Apr	81.7	17.5	11.3	2
28 Apr	87.6	18.4	11.8	3
29 Apr	84.2	17.9	12.4	1
30 Apr	89.1	16.9	12.5	1
01 May	98.6	17.3	12.0	0
02 May	101.0	17.2	11.6	4

Appendix Table 11. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
03 May	113.2	22.9	11.6	0
04 May	118.6	25.0	12.2	0
05 May	121.9	28.5	12.7	2
06 May	125.2	26.6	13.2	1
07 May	125.8	25.0	13.3	0
08 May	128.0	27.1	13.3	4
09 May	134.6	33.4	13.2	3
10 May	128.9	28.7	13.0	2
11 May	124.1	24.5	13.0	2
12 May	118.7	22.0	13.0	4
13 May	129.0	27.5	12.8	1
14 May	115.1	20.5	12.4	1
15 May	125.7	29.3	12.3	2
16 May	125.1	27.4	12.5	0
17 May	125.2	23.6	12.5	2
18 May	128.8	26.6	12.3	0
19 May	125.0	26.8	12.2	4
20 May	128.4	32.1	12.3	0
21 May	118.4	27.4	12.7	1
22 May	143.1	42.1	12.9	0
23 May	172.1	70.5	13.4	1
24 May	179.3	78.2	13.6	0
25 May	166.2	63.5	13.2	0
26 May	179.4	79.0	12.3	0
27 May	211.5	110.0	11.9	3
28 May	221.3	120.5	12.2	1
29 May	191.8	92.3	12.0	2
30 May	198.0	100.9	12.0	0
31 May	174.8	87.6	12.4	1
01 Jun	162.7	66.9	12.9	1
02 Jun	153.0	66.2	13.6	0
03 Jun	155.7	64.0	14.1	0
04 Jun	144.1	49.6	14.2	1
05 Jun	147.3	51.4	14.6	0

Appendix Table 11. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
06 Jun	138.8	39.9	14.9	0
07 Jun	130.3	36.8	14.9	1
08 Jun	123.1	30.4	14.8	1
09 Jun	128.2	33.1	14.9	1
10 Jun	119.3	28.4	14.8	0
11 Jun	118.6	23.4	14.9	1
12 Jun	112.6	18.1	15.4	0
13 Jun	122.8	20.3	15.5	1
14 Jun	120.3	17.0	15.7	1
15 Jun	122.2	17.1	16.0	0
16 Jun	116.9	17.8	15.9	1
17 Jun	114.4	18.4	15.9	0
18 Jun	104.2	17.1	16.0	0
19 Jun	94.6	21.4	16.0	0
20 Jun	100.4	26.2	16.4	0
21 Jun	96.6	0.0	16.4	0
22 Jun	94.3	0.1	16.2	0
23 Jun	91.4	0.3	15.9	0
24 Jun	90.4	0.0	16.0	0
25 Jun	86.1	0.0	16.1	0
26 Jun	94.7	0.0	16.0	0
27 Jun	109.2	0.0	16.1	0
28 Jun	106.5	0.0	16.7	0
29 Jun	96.7	0.0	17.6	0
30 Jun	87.8	0.0	18.0	0
01 Jul	82.1	7.4	17.5	0
02 Jul	81.9	0.0	17.3	0
03 Jul	82.4	0.0	17.1	0
04 Jul	88.8	0.9	17.2	0
05 Jul	84.9	0.0	17.6	0
06 Jul	76.3	0.0	18.4	0
07 Jul	72.1	0.0	19.3	0
08 Jul	66.4	0.0	19.6	0
09 Jul	69.8	0.0	20.3	0

Appendix Table 11. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
10 Jul	63.0	0.0	20.6	0
11 Jul	68.3	0.0	20.1	0
12 Jul	73.3	0.0	20.3	0
13 Jul	63.8	0.0	20.4	0
14 Jul	66.3	0.0	20.6	0
15 Jul	65.4	0.0	21.1	1
16 Jul	61.9	0.0	21.5	0
17 Jul	58.1	0.0	22.0	0
18 Jul	57.5	0.0	21.7	0
19 Jul	56.1	0.0	21.8	0
20 Jul	59.6	0.0	21.7	0
21 Jul	57.8	0.0	22.0	0
22 Jul	53.8	0.0	22.0	0
23 Jul	61.8	0.0	21.9	0
24 Jul	53.8	0.0	21.8	0
25 Jul	56.6	0.0	21.8	0
26 Jul	54.2	0.0	22.7	0
27 Jul	56.1	0.0	22.5	0
28 Jul	55.1	0.0	22.3	0
29 Jul	53.8	0.0	22.8	0
30 Jul	54.3	0.0	23.1	0
31 Jul	52.9	0.0	21.7	0
01 Aug	55.5	0.0	21.5	0

Appendix Table 12. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at McNary Dam during 1998, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
24 Apr	194.1	75.3	10.9	0
25 Apr	180.3	69.9	10.7	0
26 Apr	184.6	70.1	11.1	0
27 Apr	200.1	69.9	12.0	1
28 Apr	198.5	70.0	12.1	2
29 Apr	196.9	70.0	12.3	1
30 Apr	217.2	64.0	12.3	0
01 May	230.7	69.9	12.6	1
02 May	225.4	74.9	12.5	0
03 May	278.8	120.1	12.6	3
04 May	279.0	119.1	13.6	1
05 May	295.9	130.8	13.4	0
06 May	328.0	164.2	13.2	0
07 May	337.8	163.5	13.2	0
08 May	339.7	165.6	13.0	0
09 May	360.5	185.9	12.8	1
10 May	329.3	157.4	12.6	1
11 May	300.4	135.1	12.5	0
12 May	309.6	139.3	12.7	0
13 May	326.5	152.1	12.4	0
14 May	327.4	147.2	12.1	2
15 May	333.4	153.9	12.0	0

Appendix Table 12. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
16 May	317.6	139.2	12.0	0
17 May	296.9	120.6	11.8	1
18 May	293.6	124.9	11.7	1
19 May	315.2	149.9	12.2	0
20 May	308.1	146.1	12.4	1
21 May	312.5	142.6	12.4	1
22 May	293.1	133.7	12.3	0
23 May	284.4	132.8	12.5	0
24 May	317.3	156.3	13.3	0
25 May	287.0	142.2	13.4	0
26 May	306.1	147.2	13.4	1
27 May	379.6	206.8	13.2	0
28 May	400.1	238.2	12.9	1
29 May	409.0	251.0	12.6	0
30 May	414.3	244.1	12.8	0
31 May	394.4	226.2	12.9	0
01 Jun	366.8	195.4	13.0	0
02 Jun	385.0	230.0	13.5	0
03 Jun	405.4	237.3	13.7	0
04 Jun	390.8	223.2	14.0	1
05 Jun	353.5	180.8	14.6	0
06 Jun	373.3	202.5	15.2	1
07 Jun	316.8	160.0	15.5	0

Appendix Table 13. Monthly flow information from August 1997 through July 1998 in cubic feet per second (cfs) for various sites in the Salmon River drainage in Idaho. These data were provided by the U.S. Geological Survey and are cited as provisional data subject to revision.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Station number 13295000--Valley Creek at Stanley, ID												
Mean	192	146	137	114	104	103	86	101	196	470	533	325
Min	129	118	107	81	77	90	75	74	115	336	454	174
Max	290	219	260	170	122	115	100	180	440	599	883	560
Station number 13302500--Salmon River at Salmon, ID												
Mean	1946	1505	1704	1632	1289	1288	1170	1300	4090	5356	5356	4093
Min	1340	1280	1320	1380	1100	1120	1090	1090	2840	4210	4210	2280
Max	2690	2050	1970	2130	1570	1420	1240	1700	5160	7070	7070	6560
Station number 13310700--South Fork Salmon River near Krassel Ranger Station, ID												
Mean	260	194	184	191	157	157	159	370	638	2034	1693	642
Min	192	162	156	152	93	140	137	142	388	1320	1220	338
Max	391	243	393	239	190	180	174	1170	1450	2940	2100	1350
Station number 13314300--South Fork Salmon River at mouth near Mackay Bar, ID												
Mean	1002	676	674	14Jan	559	577	560	1066	1905	7457	6391	2535
Min	694	571	560	6Jul	347	444	477	486	1190	4650	4580	1390
Max	1390	854	1610	1290	754	665	622	2960	4430	10900	8200	4920
Station number 13317000--Salmon River at White Bird, ID												
Mean	8105	5711	5929	6042	4521	4678	4548	6718	10473	36455	33797	16904
Min	5820	5040	5150	4720	3640	4070	4200	4110	7040	24200	28400	9460
Max	10700	7010	8070	9090	13100	5030	4800	14400	21600	48700	39500	28400

Appendix Table 14. Monthly environmental data collected from Marsh Creek (RKm 179.5 from the mouth of the Middle Fork Salmon River) from August 1997 through July 1998.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.5	4.9	2.3	0.7	0.1	0.4	0.3	0.6	1.0	2.5	5.0	8.7
Maximum	15.0	11.8	6.6	3.8	1.5	2.6	3.1	5.2	7.4	8.7	10.9	15.1
Average	11.4	8.2	4.2	2.0	0.8	1.2	1.4	2.4	3.8	5.2	7.7	11.5
						Dissolved Oxygen (ppm)						
Minimum	--	8.53	9.55	11.27	12.46	12.72	12.58	10.62	10.39	--	--	--
Maximum	--	10.26	10.97	12.52	13.25	13.32	13.88	11.96	12.06	--	--	--
Average	--	9.35	10.22	11.80	12.76	13.02	13.20	11.28	11.19	--	--	--
						Specific Conductance (µS/cm)						
Minimum	58.5	60.2	58.9	54.5	55.7	54.3	49.8	55.0	52.7	38.9	44.2	51.8
Maximum	60.7	62.6	61.9	59.1	58.8	57.0	53.2	60.8	56.2	42.8	46.5	54.2
Average	59.5	61.4	60.5	57.0	57.5	55.7	51.7	58.5	54.6	41.0	45.3	53.0
						Turbidity (ntu)						
Minimum	1.12	0.57	0.74	0.31	0.20	0.40	0.04	0.47	2.17	4.76	3.57	1.11
Maximum	2.39	1.42	5.69	1.65	4.85	3.25	0.86	2.45	6.78	15.81	37.23	3.34
Average	1.61	0.90	1.79	0.67	0.75	0.95	0.27	0.84	3.68	7.25	8.33	1.73
						Depth (feet)						
Minimum	1.95	1.34	1.22	0.89	1.59	1.11	0.46	--	0.21	0.61	0.88	1.06
Maximum	2.09	1.46	1.40	1.09	1.92	1.48	0.70	--	0.39	0.87	1.04	1.20
Average	2.03	1.40	1.31	0.98	1.76	1.30	0.57	--	0.28	0.73	0.95	1.13
						pH						
Minimum	7.54	7.40	7.51	7.46	7.38	7.47	7.52	7.46	7.34	7.07	7.25	7.37
Maximum	8.44	8.09	8.13	8.04	7.89	7.62	7.82	7.83	7.97	7.44	7.65	7.91
Average	7.86	7.63	7.70	7.62	7.51	7.52	7.63	7.60	7.58	7.22	7.42	7.58

Appendix Table 15. Monthly environmental data collected from the Salmon River near Sawtooth Hatchery (RKm 627.9) from August 1997 through July 1998.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	11.0	--	--	1.5	0.8	0.8	0.8	1.6	3.3	5.2	7.2	10.4
Maximum	15.2	--	--	4.0	2.3	2.8	3.9	6.5	9.4	10.2	12.1	15.0
Average	12.9	--	--	2.7	1.6	1.7	2.2	4.0	6.3	7.6	9.5	12.6
						Dissolved Oxygen (ppm)						
Minimum	7.91	--	--	10.02	10.24	8.89	7.41	10.81	10.22	10.27	9.96	8.29
Maximum	10.94	--	--	10.95	10.90	9.64	8.53	12.82	12.67	12.56	12.12	10.54
Average	8.99	--	--	10.44	10.52	9.21	7.86	11.74	11.31	11.31	10.93	9.23
						Specific Conductance (µS/cm)						
Minimum	103.3	--	--	125.2	126.9	124.0	122.5	129.8	118.8	69.4	59.5	68.7
Maximum	106.5	--	--	130.2	136.2	129.2	134.6	134.4	123.6	73.2	63.5	74.4
Average	104.9	--	--	127.8	131.6	126.6	131.1	132.2	121.7	71.3	61.7	72.1
						Turbidity (ntu)						
Minimum	--	--	--	0.39	0.09	2.25	0.20	0.34	1.44	8.57	8.75	3.99
Maximum	--	--	--	6.12	7.96	20.03	7.00	3.73	11.00	27.95	19.76	18.18
Average	--	--	--	1.32	1.17	8.45	1.31	1.13	3.78	15.24	11.31	6.69
						Depth						
Minimum	0.89	--	--	1.76	1.91	1.58	1.48	2.54	2.72	3.51	3.89	3.33
Maximum	1.16	--	--	1.93	2.31	1.79	1.77	2.68	2.89	3.66	4.05	3.58
Average	1.02	--	--	1.84	2.09	1.69	1.64	2.61	2.80	3.58	3.97	3.51
						pH						
Minimum	--	--	--	8.14	8.18	8.18	8.13	7.96	7.90	7.72	7.61	7.59
Maximum	--	--	--	8.40	8.46	8.57	8.76	8.42	8.48	8.23	8.15	8.08
Average	--	--	--	8.24	8.28	8.31	8.36	8.14	8.13	7.90	7.81	7.80

Appendix Table 16. Monthly environmental data collected from Valley Creek (RKm 609.4 from the mouth of the Salmon River) from August 1997 through July 1998.

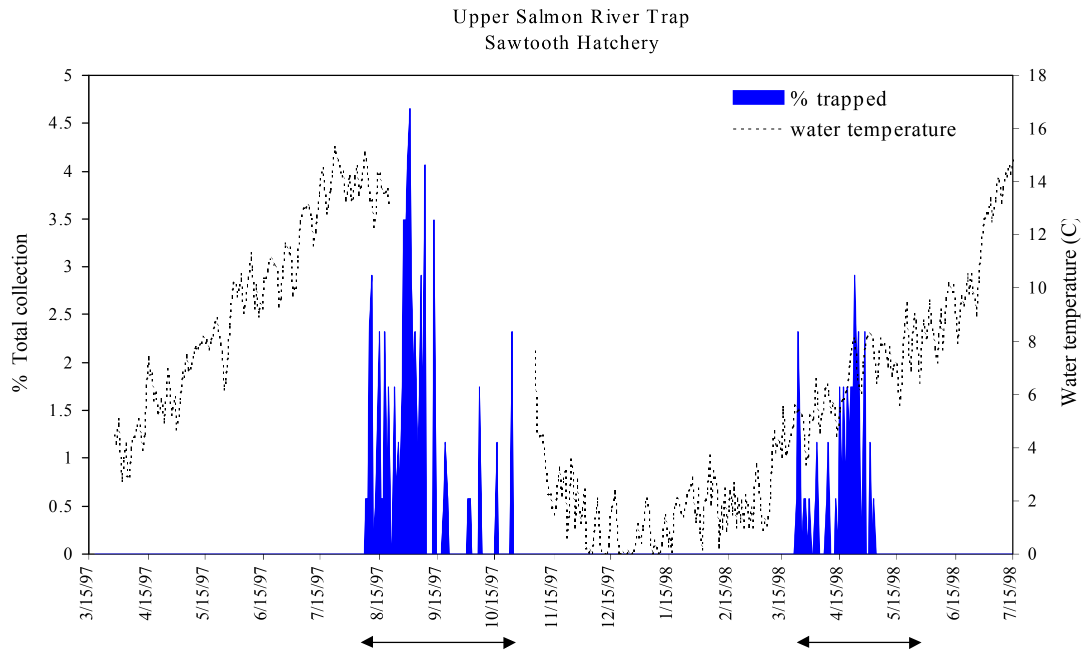
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.8	7.8	2.9	0.6	0.2	0.2	0.3	0.7	1.9	4.8	7.2	10.6
Maximum	15.5	14.2	7.8	3.4	0.5	0.6	1.4	5.1	9.0	10.1	12.2	15.5
Average	11.7	10.7	5.1	1.7	0.3	0.4	0.6	2.5	5.1	7.4	9.4	12.8
						Dissolved Oxygen (ppm)						
Minimum	7.68	8.71	10.81	11.86	13.06	13.88	13.57	10.82	9.86	9.60	9.23	7.75
Maximum	9.33	10.42	12.66	12.86	13.60	13.80	14.15	12.09	11.82	11.25	11.23	9.54
Average	8.44	9.50	11.65	12.36	13.28	13.55	13.85	11.47	10.80	10.35	10.02	8.49
						Specific Conductance (µS/cm)						
Minimum	67.5	70.5	71.1	56.4	63.3	64.2	65.9	65.5	56.9	41.4	38.6	39.5
Maximum	69.9	73.1	74.5	63.0	66.4	67.0	72.0	71.0	61.1	43.9	40.8	42.6
Average	68.6	71.8	72.7	60.3	64.8	65.8	69.0	68.2	59.2	42.7	39.7	41.4
						Turbidity (ntu)						
Minimum	0.99	0.68	0.41	0.44	3.02	5.32	0.35	1.07	4.11	3.95	2.93	0.83
Maximum	2.12	2.02	1.47	1.59	4.76	7.61	3.95	11.53	25.27	24.42	13.82	6.49
Average	1.40	1.25	0.83	0.84	3.71	6.26	1.33	3.70	10.03	8.28	5.67	1.96
						Depth (feet)						
Minimum	1.36	1.35	1.23	0.99	1.18	0.84	0.77	1.41	1.77	2.51	2.74	2.10
Maximum	1.53	1.52	1.44	1.22	1.40	1.04	1.80	1.58	1.99	2.70	2.92	2.31
Average	1.45	1.44	1.33	1.12	1.29	0.94	0.87	1.49	1.87	2.60	2.83	2.23
						pH						
Minimum	7.43	7.52	7.51	7.61	7.53	7.50	7.71	7.54	7.41	7.22	7.11	7.32
Maximum	7.96	8.19	8.15	8.01	8.24	8.31	8.52	8.05	8.09	7.65	7.68	8.04
Average	7.65	7.76	7.72	7.74	7.71	7.71	7.94	7.78	7.67	7.40	7.34	7.59

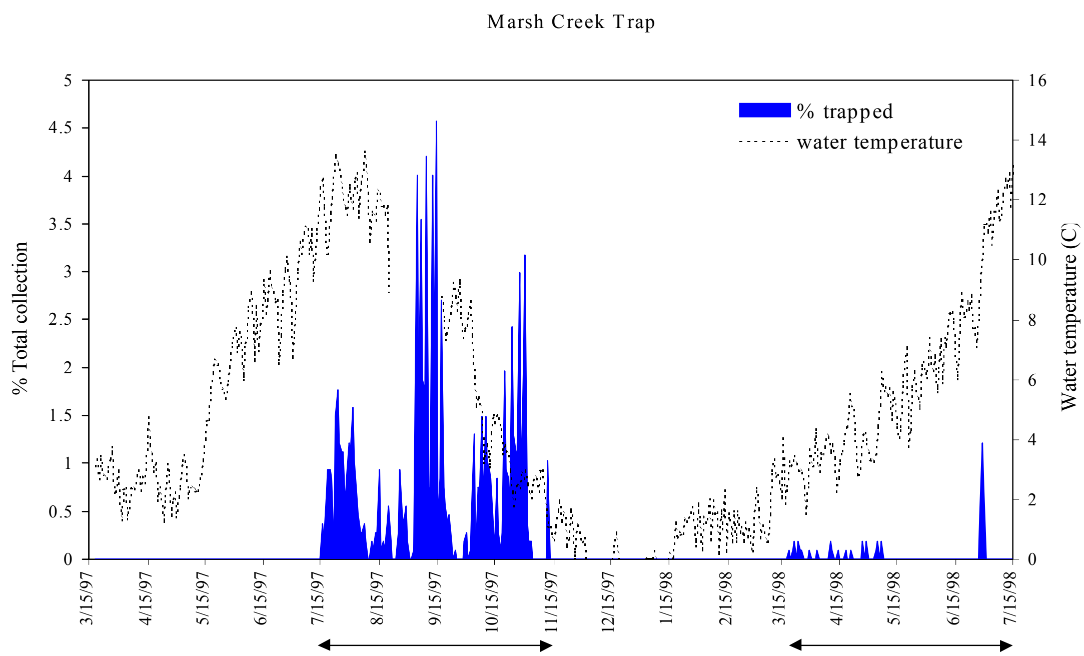
Appendix Table 17. Monthly environmental data collected from Secesh River (RKm 27 from its mouth at S. F. Salmon River) from August 1997 through July 1998.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	9.4	7.4	2.1	0.7	--	--	--	--	0.7	2.3	5.3	10.6
Maximum	15.0	12.1	5.1	3.2	--	--	--	--	5.0	5.9	8.8	14.9
Average	12.1	9.7	3.4	1.8	--	--	--	--	2.6	4.0	7.0	12.7
						Dissolved Oxygen (ppm)						
Minimum	8.63	9.85	12.10	11.47	11.48	11.73	12.08	12.49	11.99	11.58	10.83	8.31
Maximum	10.70	12.90	14.10	12.07	11.77	11.88	12.32	12.87	13.19	12.88	12.29	9.72
Average	9.52	10.90	12.77	11.73	11.62	11.80	12.19	12.64	12.58	12.27	11.54	8.95
						Specific Conductance (µS/cm)						
Minimum	29.9	32.7	34.4	25.4	32.4	33.0	34.0	32.0	27.3	16.9	18.9	23.6
Maximum	32.8	36.4	37.3	31.5	33.1	33.7	34.1	33.2	29.5	18.8	20.2	26.8
Average	31.3	34.4	35.8	29.3	32.7	33.5	34.0	32.6	28.6	17.8	19.5	25.5
						Turbidity (ntu)						
Minimum	0.93	0.33	0.70	0.18	0.04	0.00	0.00	0.42	0.98	2.15	0.85	1.01
Maximum	3.25	1.06	2.72	2.87	0.37	0.30	0.23	1.46	5.42	9.87	3.41	8.15
Average	1.68	0.59	1.37	0.66	0.14	0.09	0.05	0.80	2.34	4.27	1.61	2.24
						Depth (feet)						
Minimum	0.82	0.68	0.63	0.59	1.13	1.50	1.64	2.10	0.98	2.61	2.77	1.76
Maximum	0.99	0.83	0.84	0.85	1.34	1.75	1.95	2.40	1.22	2.95	3.01	2.01
Average	0.90	0.75	0.73	0.73	1.23	1.63	1.79	2.26	1.09	2.75	2.88	1.91
						pH						
Minimum	7.17	7.30	7.33	7.02	6.90	6.98	7.02	6.95	7.00	6.81	6.77	6.99
Maximum	8.02	8.51	7.96	7.26	6.96	7.00	7.06	7.05	7.16	6.99	7.02	7.56
Average	7.47	7.71	7.54	7.13	6.93	6.99	7.04	6.99	7.07	6.89	6.89	7.22

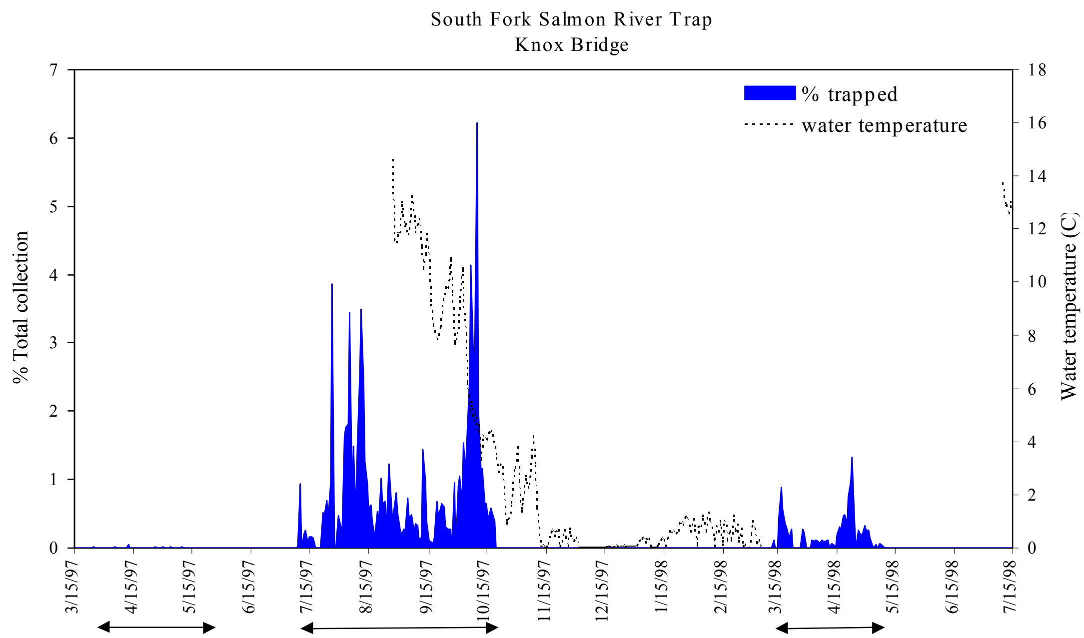
Appendix Table 18. Monthly environmental data collected from South Fork Salmon River (RKm 112 from its mouth at the Salmon River) from August 1997 through July 1998.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	9.0	8.4	3.2	0.6	0.1	0.2	0.3	0.2	--	--	--	10.6
Maximum	14.5	12.5	5.6	2.0	0.1	0.9	1.6	2.0	--	--	--	15.5
Average	11.7	10.4	4.4	1.1	0.1	0.5	0.7	0.9	--	--	--	12.9
						Dissolved Oxygen (ppm)						
Minimum	8.76	9.10	10.94	10.87	10.75	10.52	10.61	11.30	--	--	--	8.09
Maximum	10.11	10.30	11.93	11.41	11.02	10.76	11.05	11.71	--	--	--	9.37
Average	9.31	9.61	11.39	11.14	10.87	10.63	10.81	11.50	--	--	--	8.67
						Specific Conductance (μS/cm)						
Minimum	49.8	52.7	51.5	40.6	42.3	42.6	41.5	51.1	--	--	--	32.4
Maximum	52.0	55.6	55.7	46.7	45.0	44.5	47.9	57.7	--	--	--	34.5
Average	50.9	54.1	53.5	44.3	43.6	43.6	45.7	54.8	--	--	--	33.5
						Turbidity (ntu)						
Minimum	--	--	1.20	0.32	0.30	0.33	0.21	0.03	--	--	--	2.59
Maximum	--	--	18.40	1.33	3.87	1.59	1.22	1.31	--	--	--	8.56
Average	--	--	6.49	0.60	0.75	0.58	0.47	0.34	--	--	--	3.85
						Depth (feet)						
Minimum	1.75	1.67	0.90	0.83	1.50	0.67	0.54	0.90	--	--	--	1.19
Maximum	1.86	1.86	1.15	1.09	1.79	0.94	0.82	1.23	--	--	--	1.34
Average	1.80	1.76	1.02	0.97	1.63	0.81	0.68	1.04	--	--	--	1.26
						pH						
Minimum	7.39	7.49	7.53	7.43	7.44	7.54	7.50	7.24	--	--	--	7.31
Maximum	7.97	8.04	7.88	7.62	7.58	7.69	7.75	7.49	--	--	--	7.71
Average	7.59	7.67	7.65	7.51	7.49	7.59	7.58	7.36	--	--	--	7.46

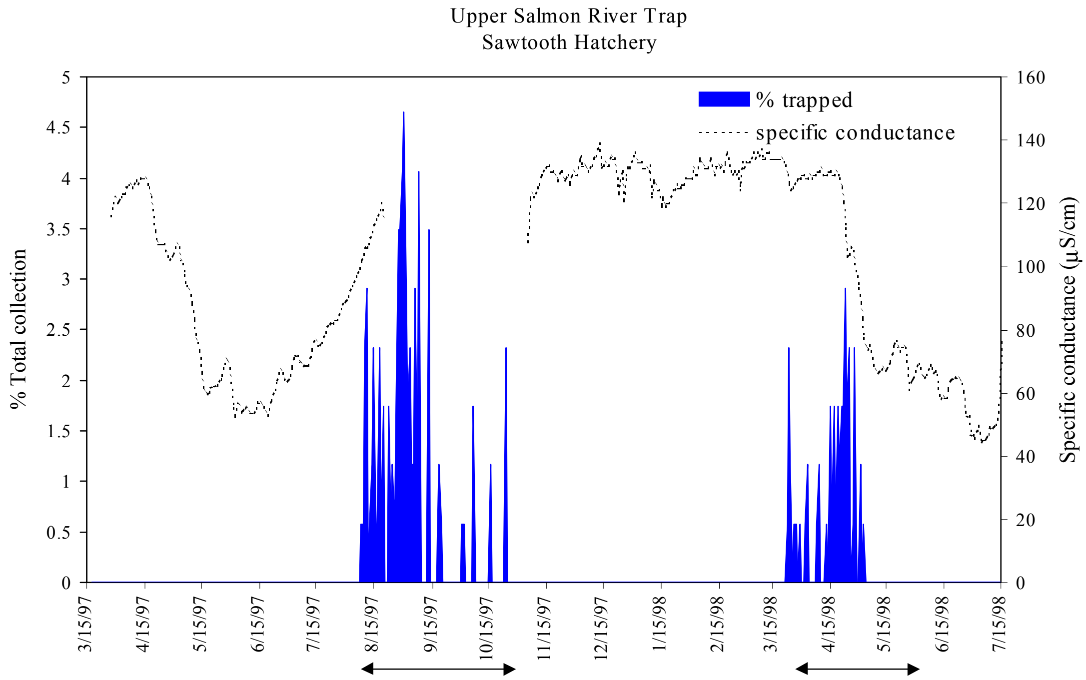


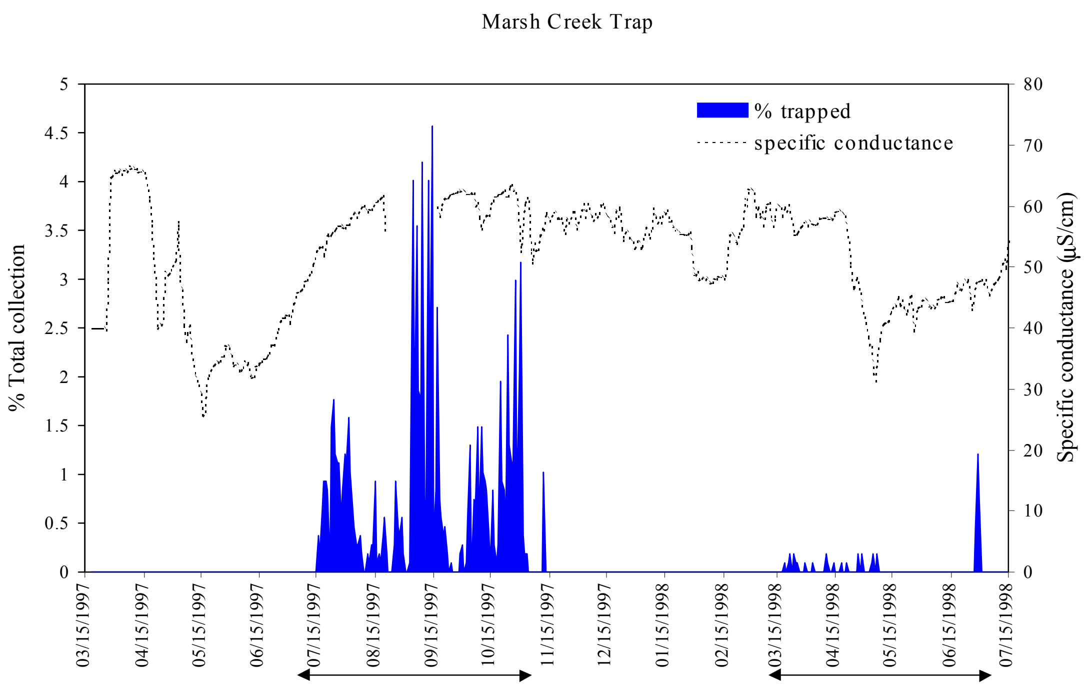


Appendix Figure 1. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water temperatures measured near the traps. Arrows indicate trap operation time.

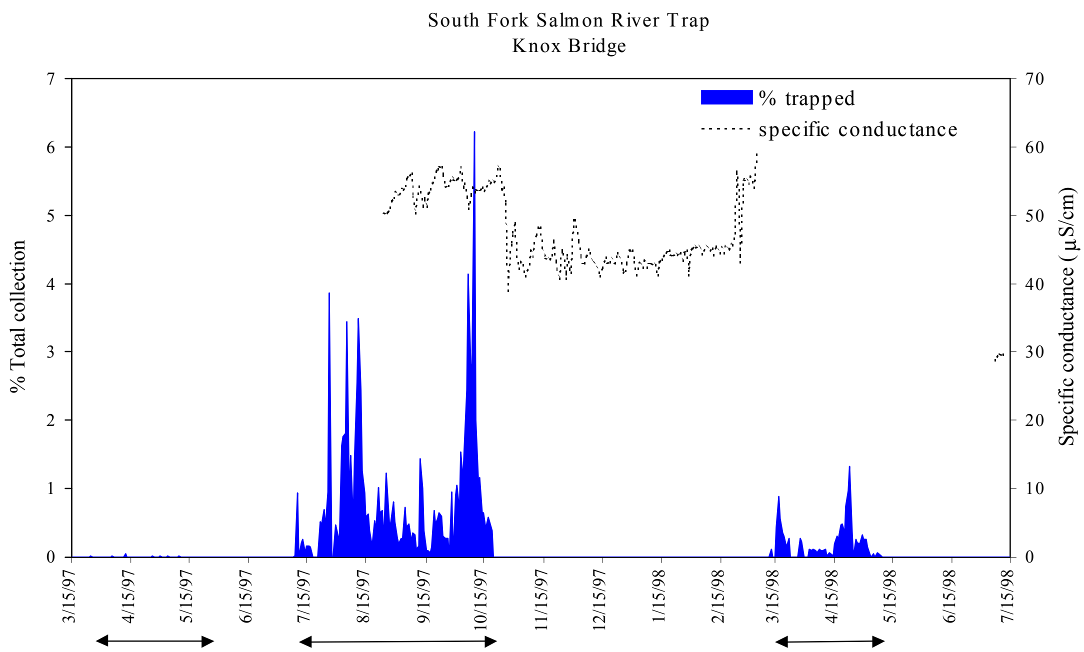


Appendix Figure 1. Continued.

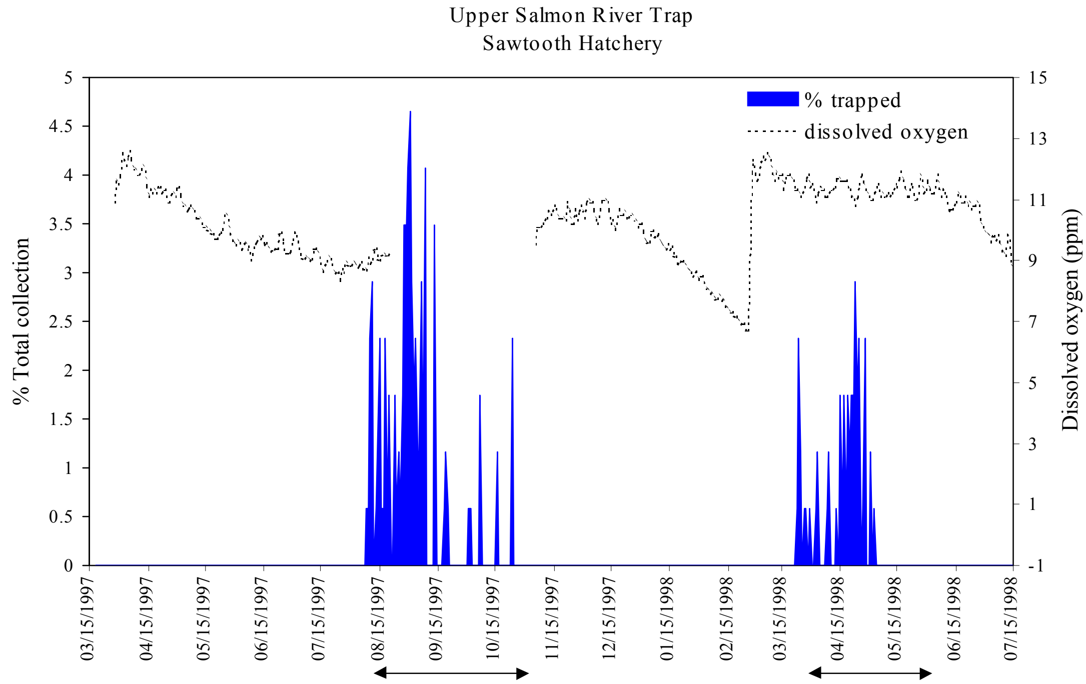


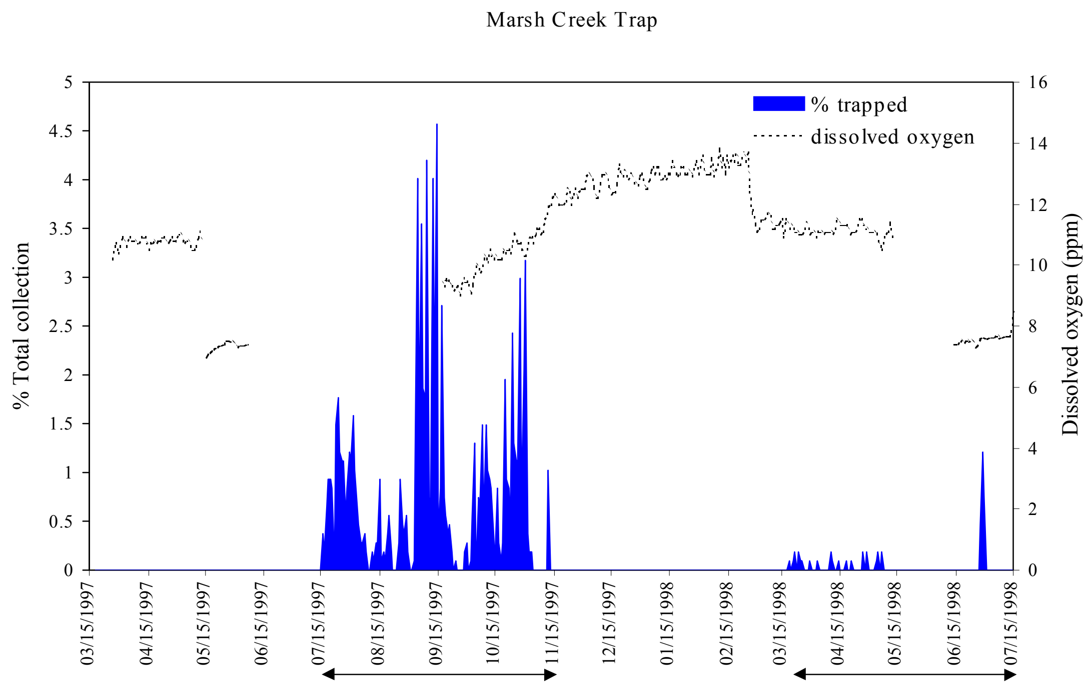


Appendix Figure 2. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water conductivity measured near the traps. Arrows indicate trap operation time.

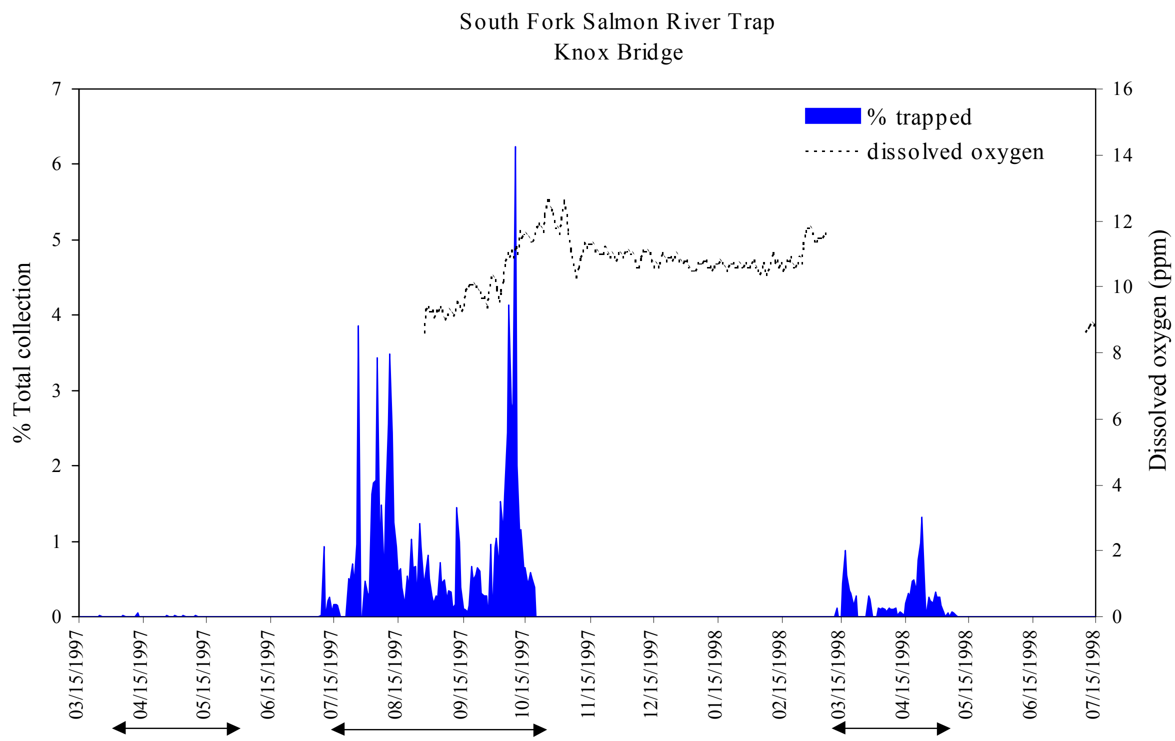


Appendix Figure 2. Continued.

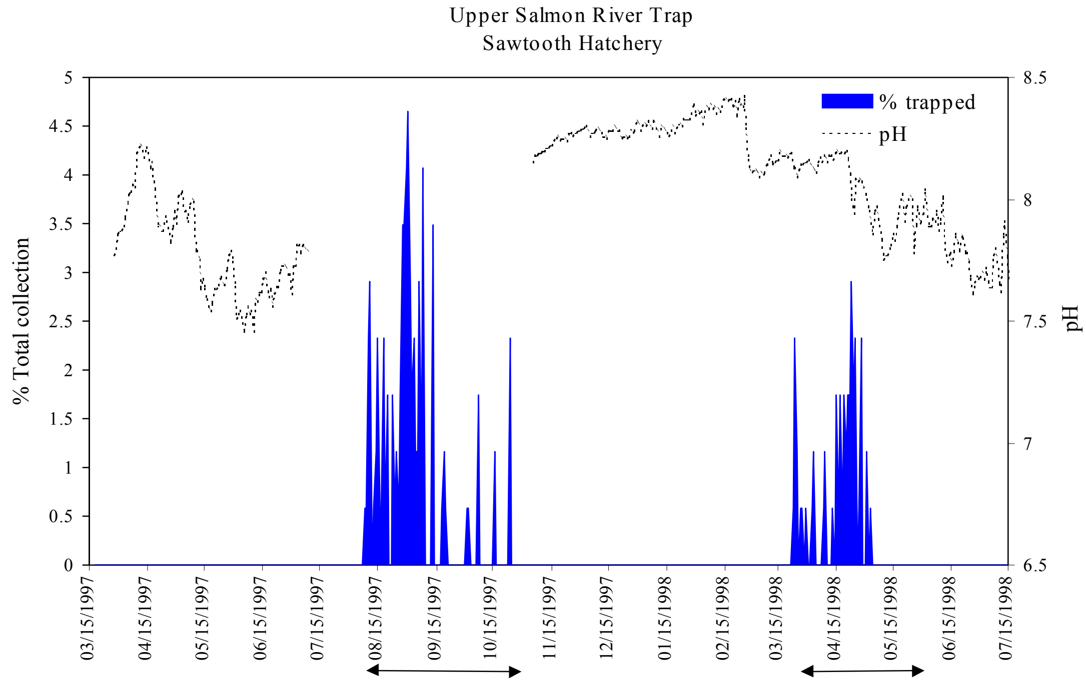


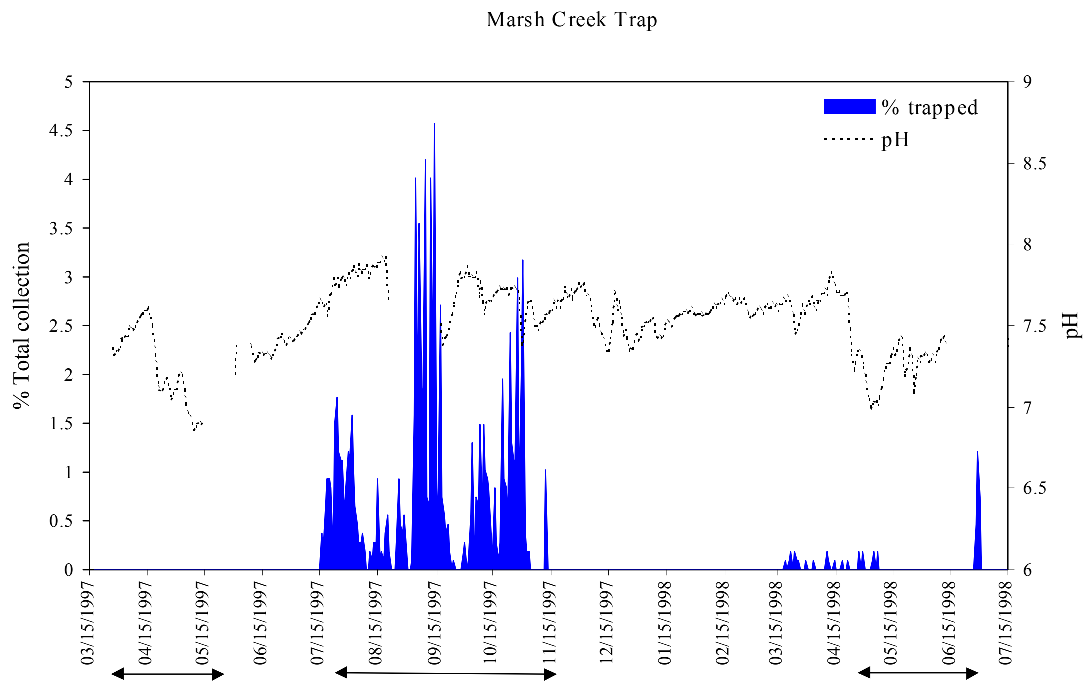


Appendix Figure 3. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water dissolved oxygen measured near the traps. Arrows indicate trap operation time.



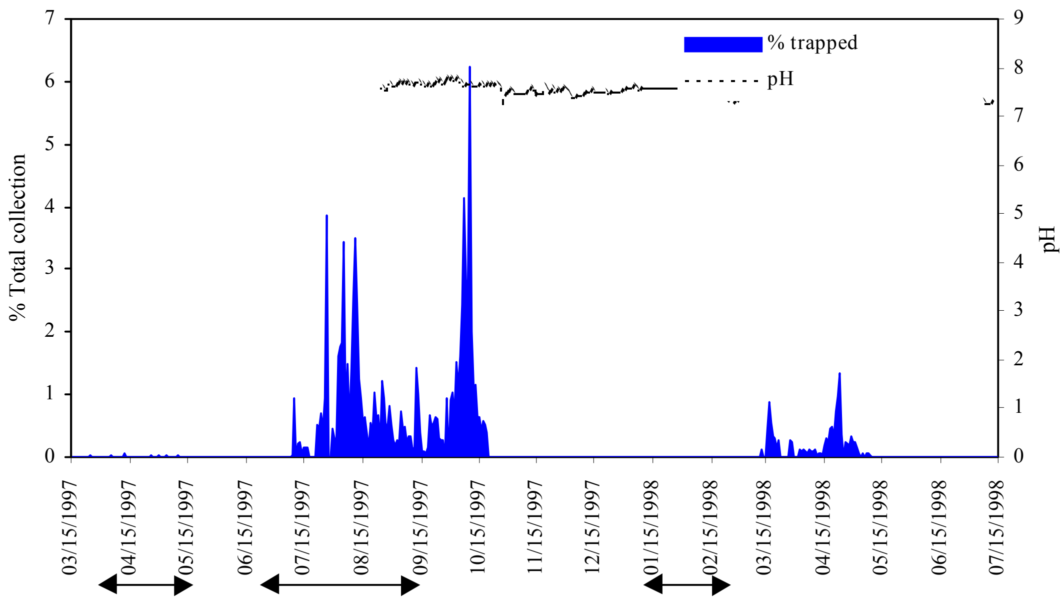
Appendix Figure 3. Continued.





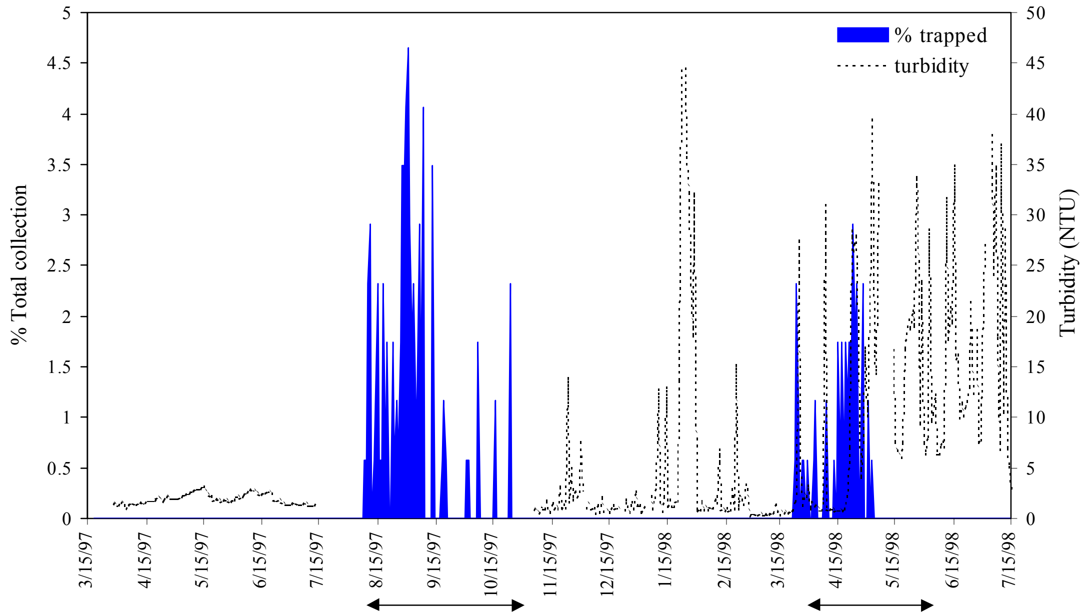
Appendix Figure 4. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water pH measured near the traps. Arrows indicate trap operation time.

South Fork Salmon River Trap
Knox Bridge

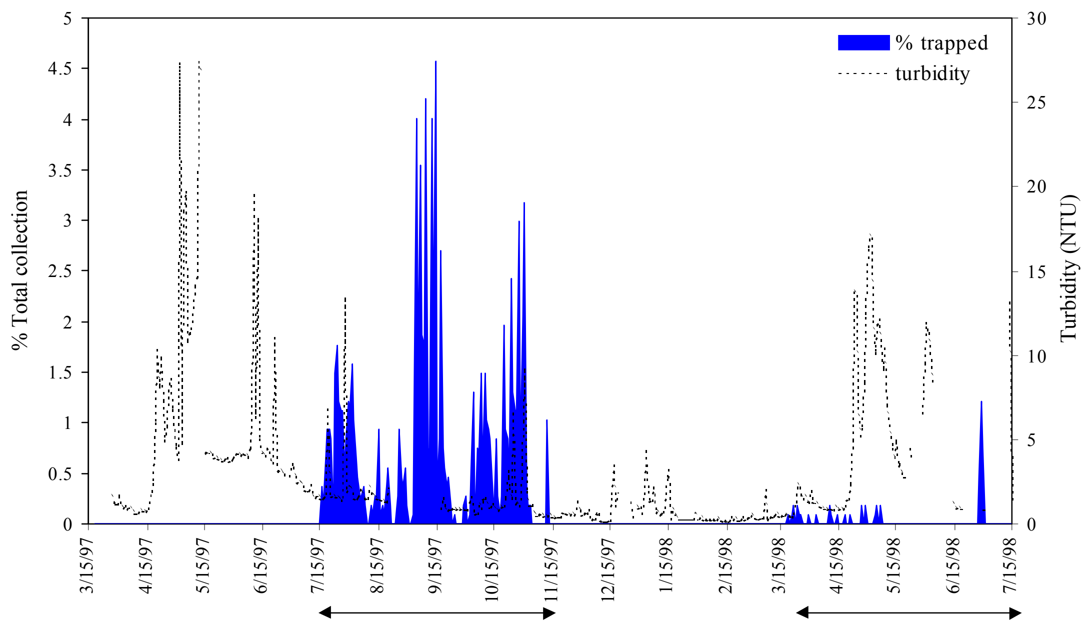


Appendix Figure 4. Continued.

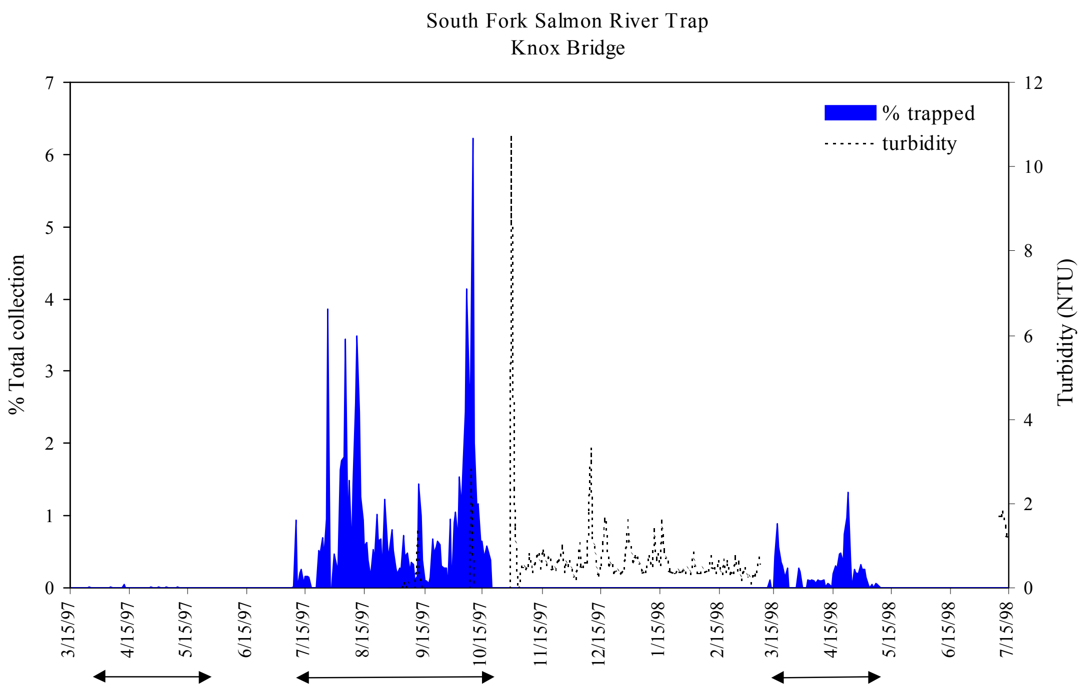
Upper Salmon River Trap
Sawtooth Hatchery



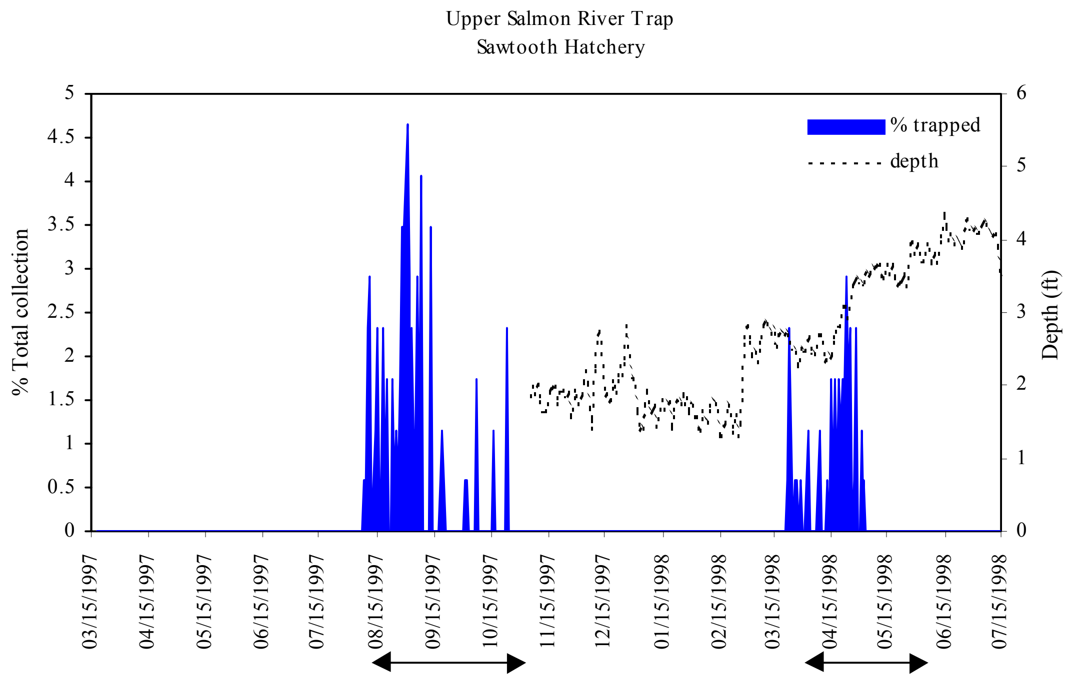
Marsh Creek Trap

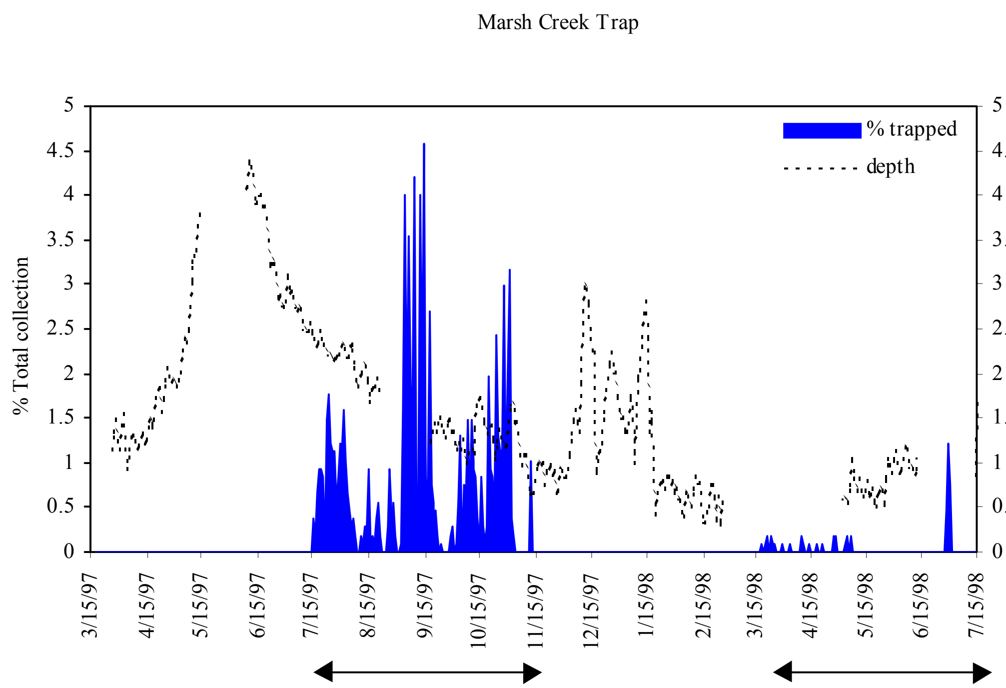


Appendix Figure 5. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water turbidity measured near the traps. Arrows indicate trap operation time.

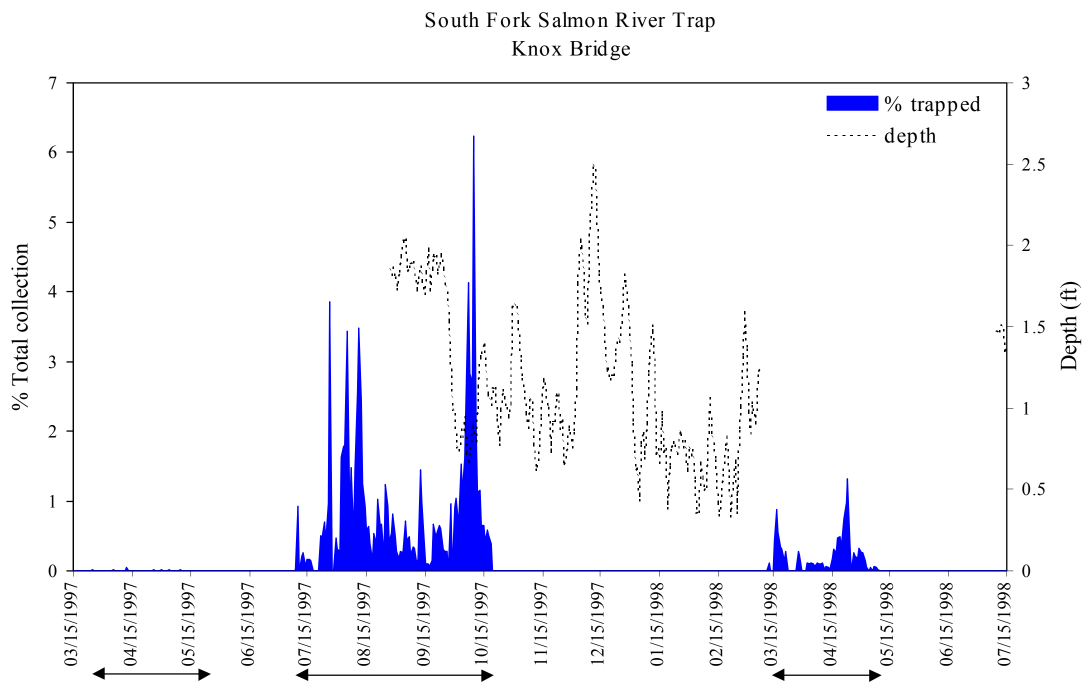


Appendix Figure 5. Continued.





Appendix Figure 6. Daily passage of wild chinook salmon fry, parr, and smolts at three migrant traps, expressed as percentages of total collected, and plotted against average daily water depth observed near the traps. Arrows indicate trap operation time.



Appendix Figure 6. Continued.